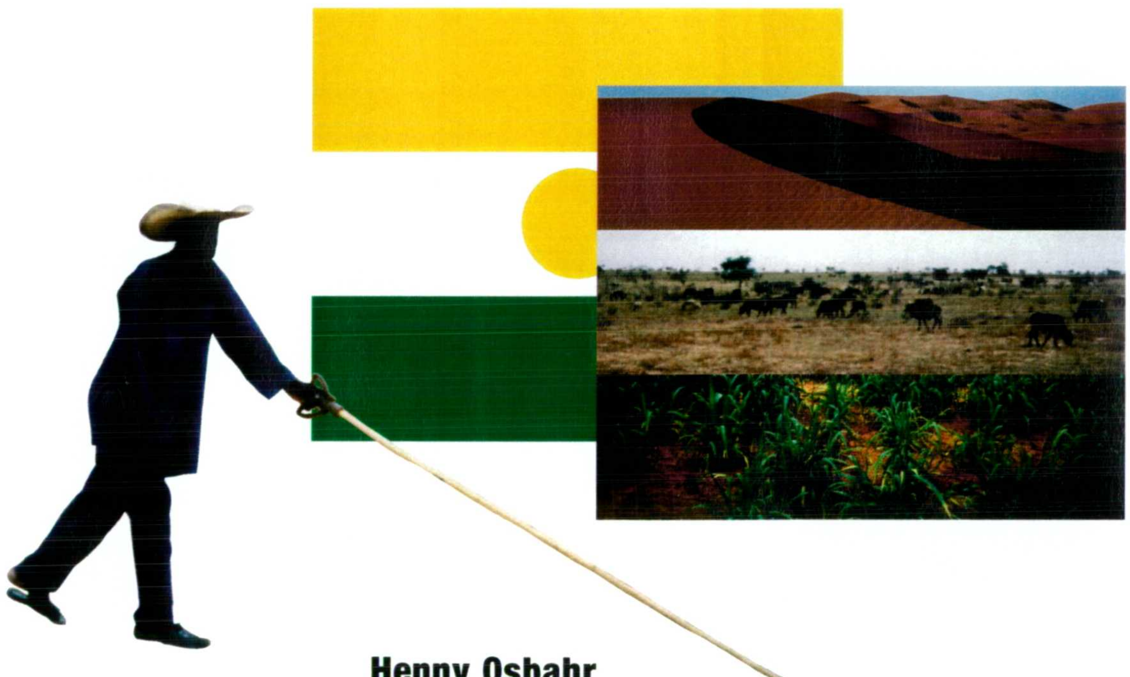
Livelihood strategies and soil fertility at Fandou Béri, southwestern Niger



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Submitted for the degree of
Doctor of Philosophy in Geography
at University College London

2001

Abstract

This is a study of the relationship between livelihood strategies, soil fertility investment and land use in the village of Fandou Béri, southwestern Niger. The aim has been to place alleged soil degradation in a specific, differentiated and dynamic local context. The village, which is populated by Djerma and Fulani, has a low population density. The agricultural system is dominated by millet cultivation on poor soils. It now depends on short-fallow periods to restore fertility, other sources of inputs being limited. There are high erosion rates and an annual precipitation of 600mm with high variability. The local narrative can be interpreted to represent this landscape as a lifescape': an environment that is a product of a complex sequence of agricultural decisions and livelihood responses. The flexibility in the ways in which the farmers manage their soil is a reflection of the ephemerality of the factors that govern soil productivity and the need to adapt to natural biodiversity and spatial variability. They relied on their local knowledge to maximise productivity, as in their precision application of organic inputs, the ways in which they are increasingly integrating smallstock into their strategies, and the increasing signs of ethnic co-operation. Using a Sustainable Rural Livelihoods framework, the key determinants of land allocation and soil investment were found to be household productive capacity, the productive potential of the land, the degree of household livelihood diversification, and the farmer's capacity to recognise opportunities, prioritise and enact entitlement. The household's endowments were dynamic and spatially differentiated. The diversity of livelihood situation, knowledge, experience, and perceptions of power and identity created many different routes of livelihood response, and varying rates of agricultural investment. Within these multiple pathways, there were dynamic transformations between natural capital and the non-farm component of rural dwellers' livelihoods.

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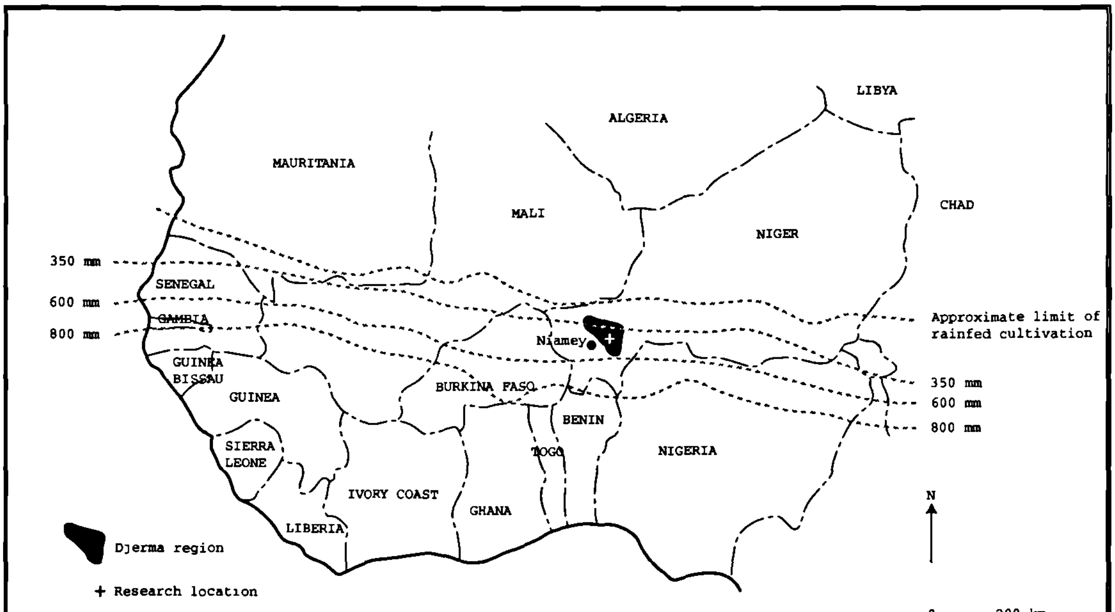
1
Introduction

1.1 The agricultural sector in Niger

The Republic of Niger is a land-locked country in the West African Sahel (map 1.1) (Raynaut, 1997). Niger is one of the larger West African countries (1.267 million km²) with 50,000 km² of arable land, 100,000 km² of grazing land. The rest is desert. There were 6.9 million inhabitants in 1990, an estimated 9.5 million in 2000 and population growth is 3% per annum (FAO, 1998). Winter and Quan (1998) estimated that 86% of the population was involved in farming. The population density for the country is low (6.5 persons/km^{-2}) but there is a concentration of the population in the south-western Niamey-Zinder area. (FAO/GIEWS, 1997).

Map 1.1: The location of the Republic of Niger in the West African Sahel



Niger is one of the poorest countries in the world in the UNDP indices on several accounts. The economy is based on primary products, from the mining industry (primarily uranium ore and salt, but also tin, coal and gypsum) and agriculture. Concentrated in the south-west, rainfed agriculture is the mainstay of the economy (plate 1.1). Unreliable and variable rainfall and poor soils create an unpredictable and difficult environment in which to farm (Bationo and Mokwunye, 1991; Bleich and Hammer, 1996; Baidu-Forson and Williams, 1996). Mean annual rainfall in this area ranges from 100 and 600mm (Koechlin, 1997). The length of the growing period (75 to 120 days) is highly dependent on the start of the rains (Sivakumar, 1993). The rainy season starts in April-June and ends in October-November.

Plate 1.1: Dryland millet farming around the study village, Fandou Béri, south-western Niger

Farming households focus on subsistence production but often in combination with pastoral activities, cash cropping and seasonal economic migration (Painter, 1987; Raynaut, 1997; Rain, 1999; de Haan, 1999; Ellis, 2000). The major cereal grown by farmers is millet, yielding an average 350 kg/ha per year over the past decade (FAO, 1998). Millet is commonly intercropped with cowpea, groundnut and sorghum. While the export market for groundnuts and cotton has become less important in recent years, vegetables and meat (livestock) for the growing urban population have remained important (plates 1.2 and 1.3).

Plate 1.2: A village vegetable and fruit garden dependent on water from the well, south-western Niger

Plate 1.3: Mixed irrigated rice and livestock farming in south-western Niger

Niger has experienced a history of repeated droughts and food shortages (the most recent in 1996-1997), dramatic changes in politics and policy, and a changeable economy and informal sector. Its economy is dependent on imported cereals, machinery, vehicles, and refined petroleum products.

The next three sections summarise the now well-worn discourse on a perceived agricultural crisis in the Sahel, which has largely been based on ambiguous evidence, and the challenge from a more robust analysis of diversity, in order to situate this study within the theoretical debate. Chapter Two reviews more fully the important issues raised, including the agricultural intensification debate, ideological constructions of sustainability, and the development of agroecological thought.

1.1.1 A crisis in agriculture?

A perception of society in the West African Sahel being at its most vulnerable, a culture of subsistence facing a crises of natural resource management and poverty, has persisted in the literature. Niger is often portrayed as the most vulnerable of the Sahelian countries. Agriculture in dry Africa is undoubtedly suffering some serious environmental, socio-economic and political problems (Bonkaungou, 1996; Weigand and Milton, 1996; Eswaran *et al.*, 1997; World Bank, 1997; Seely, 1998; Barbier, 1998). Agricultural yields in Niger are low and have grown very slowly over the last 20 years (Hopkins and Berry, 1994; FAO, 2000). Farmers still rely largely on traditional farming methods. The use of inorganic fertiliser is extremely low at 1.9 kg/ha of NPK (N + P_2O_5 + K_2O) (Henao and Baanante, 1999). The change in the labour/land ratio from 1962 to 1992 was 105% but the labour productivity decreased by 25% (Cuffaro, 1997). The reasons given for the perceived stagnation of Niger's agricultural sector in the literature are many and complex, but often with little foundation. Opinions can be grouped broadly into those that invoke soil degradation and soil fertility debate and those that invoke policy-related and productivity issues.

Many see the perceived crisis to be the result of the 'inappropriate' land-use practices, which result from population growth, overcultivation and intensification, 'traditional' tenure systems, overgrazing and deforestation, and more recently human-induced climate change (Sinclair and Fryxell, 1985; Lindskog and Tengberg, 1994; Nuru, 1996; Wiegand and Milton, 1996, Breman, 1998; de Graaff, 1998; Feddema, 1999; Sanchez, 2000; Hulme, 2001; Kelly and Kolstrad, 2001). Others suggest it is the legacy of an export-oriented phase of agricultural policy, which was associated with monetary taxation, weakened self-sufficiency, coercive production and the monetisation of the economy (Watts, 1984; 1989; Raikes, 1988; Commins *et al.*, 1996; Swift, 1996; Warren, 1996). Against the background of development intervention that has failed to bring sustained yield increases, researchers have focused on the problems of low biological productivity, long-term rainfall decline, inadequate infrastructure, social and technological conservatism, inappropriate agricultural policies, the mismanagement of tenure registration, international debt and unfavourable global market trends (Vierich and Stoop, 1990; Sivakumar, 1993; Bruce, 1993; Reenberg, 1996; Reardon *et al.*, 1997; Mkandawire and Olukoshi, 1998; Lavigne Delville, 1999).

It is true that the natural resource base for farming in Niger is low in quality and highly variable. Most soils are acidic and sandy, with low pH, and this is associated with low levels of available nutrients, especially phosphorus (Bationo and Mokwunye, 1991; Bleich and Hammer, 1996; Buerkert *et al.*, 1996; Bekunda *et al.*, 1997). The effect of erratic rainfall and drought in certain years on production trends is significant (Hunt, 2000; Vizy and Cook, 2001). Hulme (1992) reported mean rainfall to have fallen by a third in the Sahel since the 1960s while Nicholson *et al.* (2000) reported a 15-40% decrease in average rainfall between the 1931-60 and the 1968-1997 periods. There were droughts in 1968-73, 1984 and the mid-1990s. In response to crop failures in 1972 and 1973 CILSS (Comité permanent Interétat de Lutte contre la Sécheresse Sahélienne) and Club du Sahel were conceived in order to co-ordinate the flows of aid to member countries (Senegal, Mauritania, Mali, Burkina Faso, Niger and Chad). Poor rainfall in 1995-1997 led to further deterioration in Nigerien agricultural production according to some sources (Buizer *et al.*, 1998; Bell *et al.*, 1999).

Away from the fertile soils of a narrow fringe along the River Niger, woodcutting, grazing and extensive cultivation practices have reduced vegetation cover in some places, particularly in the close-settled zone around Niamey (FAOSTAT, 1998). Studies in the hinterland of Niamey, away from the river, report land intensification and crop decline (Amissah-Arthur *et al.*, 2000). Although the region has been inhabited for centuries, Spath and Francis (1994) argued that there is an 'advanced state of exhaustion' and that indigenous methods of land husbandry are under stress, mistakenly viewing habitual migration for off-farm income as a new phenomenon (de Haan, 1999).

National economic policy decisions have served to focus attention to scarcity of financial capital in many Sahelian countries, including Niger (Tshibaka, 1998; Ng'ong'ola, 1999; Adedeji, 1999). National debt and commitments to economic restructuring have led to cuts in public spending in the agricultural sector through the 1980s and 1990s (Lopez and Hathrie, 2000). Monetary devaluation in 1994 pushed up prices for farming inputs, while slumps in the agricultural commodity markets has lowered the price on crops at sale (Barrett-Brown, 1995). The policy disincentives to small-scale Nigerien farmers (see Hopkins and Berry, 1994 in Niger) can be summarised as follows: (1) continued insecurity of land holding despite the introduction of a tenure law (the Rural Code in 1992) has contributed to the failure by some farmers to invest in the long-term improvement of the soil; (2) concentration of research and production packages on those that depend on high fertiliser input and cereal-based farming systems; (3) recent political instability and the closure of agricultural projects; and (4) the high cost of fertiliser inputs following abolition of subsidies. These factors have led to diversification out of agriculture, reducing labour inputs into agriculture and reducing investment for cash-cropping.

According to Stoorvogel and Smaling (1990) the Sahel suffers moderate to high nutrient depletion. Their belief that there has been a dramatic decline in the fertility of agricultural soils, throughout Niger, is based on ambiguous evidence for shortened fallow periods, lower levels of fertiliser and manure application, complete removal of crop residues from fields and inadequate soil conservation practices. They also raised concerns that land-use decisions were driven by short-term economic decisions.

1.1.2 Soil degradation and agricultural production

Much of the literature pre-judges soils to be one of the key parameters in the analysis of the relationship between demographic pressure, land-use dynamics and land degradation processes in the Sahelian zone of West Africa (Floret *et al.*, 1993; Krogh and Paarup-Laursen, 1997). Payne (1997) showed that, outside exceptional drought years, water availability was not usually the limiting factor to production, but that low soil nutrient levels were. This contrasts with Penning de Vries and Djitèye (1992) who found aridity to be the critical factor. Any additional threat to soil quality is therefore a potential constraint to agricultural production. There is little doubt that soil degradation is perceived by many researchers to be a serious physical constraint to farmers in the West African Sahel (Adams, 1990; Lal, 1993; 2000; Swift, 1996; Crosson, 1997). Soil degradation can be defined as the temporary or permanent lowering of the productive capacity of land (Lal, 1990). The concept includes closely linked processes such as erosion, chemical degradation (loss of nutrients through crop removal, erosion, leaching), physical deterioration (surface sealing, crusting) and biological degradation (decline of soil humus content). All these forms of degradation lead to lowered soil fertility and land productivity (see Chapter Two for an explanation of these concepts).

The debate about degradation has been both extensive and controversial. Many official and influential statements have been made about the scale of degradation and its impact, and Niger is a country that is often cited in this respect. The literature, especially from United Nations sources and international environmental agencies, is replete with crisis narratives, that is, sensational and sweeping statements about the extent of environmental problems (see box 1.1).

The 'Sahel problem' has become a transnational issue, prompting institutional responses at the national level (to control desertification, erosion, deforestation, agriculture, water use, population and markets besides degradation). There have been numerous conventions and agendas for action to promote sustainability (e.g. UN Conference on the Human Environment, 1972; International Convention to Combat Desertification, 1977; UN WCED Commission on Environment and Development, 1984; IUCN Conference on Conference and Development, 1987; Rio UNCED Earth Summit, 1992; Rights of Indigenous Peoples, 1992; Convention on Biological Diversity, 1993; International Conference on Population and Development, 1994; The World Summit for Social Development, 1995; Fourth World Conference on Women, 1995; Habitat II, 1996; World Food Summit, 1996; UNCED Convention to combat desertification, 1996; UN Earth Summit II, 1997; Kyoto Protocol on Climate Change, 1997). However, these efforts have not produced sustainable livelihoods for Sahelian producers.

BOX 1.1: PROBLEMATIC INTERPRETATIONS OF SOIL DEGRADATION

- *"About 321 million hectares of sub-Saharan Africa are moderately, severely, or extremely degraded and a further 174 million hectares are lightly degraded".(WORLD BANK/CLEAVER AND SHREIBER, 1994:21)*
- *"About a half-billion hectares in Africa are moderately to severely degraded, corresponding to one third of all cropland and permanent pasture on the continent".(UNITED NATIONS/UNEP, 1997:26)*
- *"More than 80% of sub-Saharan Africa's productive drylands, some 660 million hectares, are affected by desertification". (ENVIRONMENTAL NGOs/WRI/IIED, 1987:59)*
- *"Each year, 75 billion metric tons of soil is removed from land by wind and water erosion".(PIMENTAL et al., 1995:1117)*
- *"22% of all productive land has been degraded. Cropland is most threatened in Africa with 65% degraded".(GLASOD 'Global Assessment of Land Degradation'/OLDEMANN et al., 1990)*
- *"Rehabilitation is possible but would be far more expensive than farmers can afford. For 64 countries future food production increases will enable less than half the projected year 2000 population to be fed".(NORSE, 1992/FAO, 1982)*
- *"Soil fertility depleting in smallholder farms is the fundamental biophysical limiting factor responsible for the declining per capita food production of sub-Saharan Africa. The magnitude of nutrient mining is huge. We estimate the net loss during the last 30 years to be 700kg/N, 100 kg/P and 450kg/K in about 100ha of cultivated land".(FAO/SANCHEZ et al., 1996)*

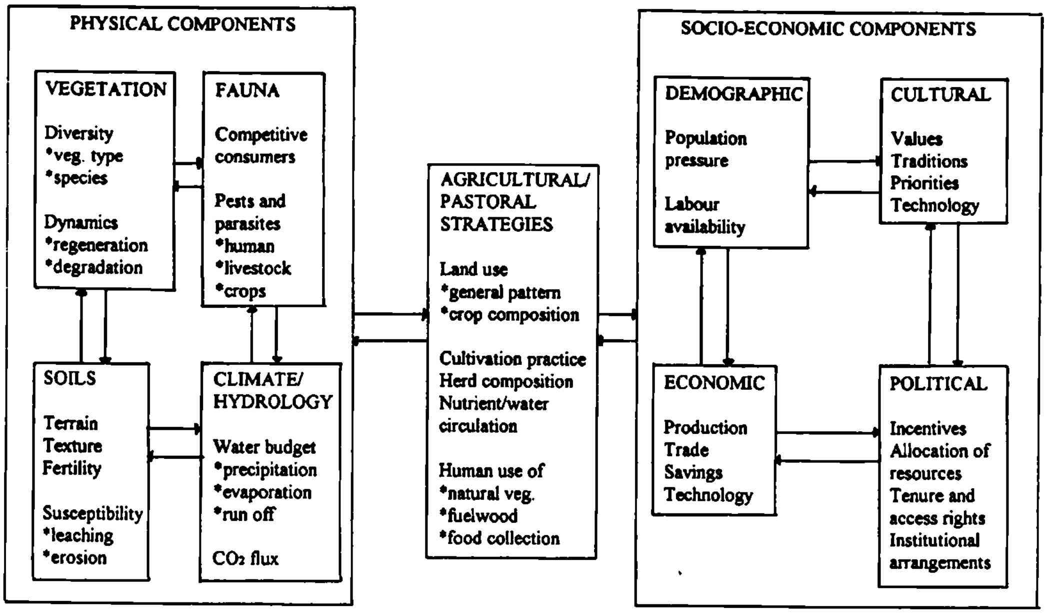
It is true that a decline in soil fertility would be serious, in terms of the biophysical changes, but also in terms of economic and social on-site and off-site costs and disruption. It is also true that soil erosion and soil fertility decline are serious in some places (see Chapter Two) and that some households may compromise the renewability of natural resources such as soils, at least in the medium-term (Turner *et al.*, 1993). However, many authorities remain convinced that a perceived spiral of poverty and declining soil fertility are major constraints to agricultural production (Griztner, 1988; Steiner, 1996; Mainguet, 1998; Breman *et al.*, 2001).

But why should farmers degrade their soil when many know that some practices jeopardise their future? Part of the answer lies in the spatial and temporal prioritisation of local livelihoods, but these processes are poorly understood. Little of the literature sees the issues from farmers' perspectives. Indeed, many farmers often do not see erosion as a problem (Östberg, 1991). Scoones and Toulmin (1999a) noted that exploiting soil capital is a rational strategy for farmers to pursue where nutrient stocks remain to be tapped and where clearing new land for such purposes is cheaper and easier than investing, either in purchase of inorganic inputs, or in the labour needed to follow low-external-input options. Farmers are only likely to moderate these practices where they see declining returns to labour as well as to land, where land starts to become scarce and where they must depend on land to make a living in the future (McDonald and Brown, 2000).

Rhetoric on soil erosion can be a useful device to displace people, point fingers of blame, promote the cause of environmental agencies and the professionals who work in agricultural research, and mobilise international aid (Stocking, 1996). To properly appreciate the threat of degradation, it is necessary to know what is expected of the land. Proper understanding of the problem is limited in Niger.

The belief in an 'agricultural crisis' is based on highly debatable assumptions and predictions and many of its arguments are tenuous. Its interpretation is often ambiguous, too many generalisations are drawn from limited empirical data and the processes involved are oversimplified (Reij *et al.*, 1996). The concept of carrying capacity has pervaded influential literature despite its discredited value (Homewood and Rogers, 1987; Behnke *et al.*, 1993; Bourn and Wint, 1994; Scoones, 1995; 1996; de Bruijn and van Dijk, 1999). For example, a World Bank study (POPLIN, 1995) estimated that the carrying capacity of the Sudano-Sahelian zone (the area between the 300-600 mm isohyets and containing more than half of the total population of the Sahel) is about 15 persons km^{-2} under present land-use practices, but such definitions are of little practical function in an environment with diverse and changeable farm management. It is especially difficult to make estimates of productive potential because of the enormous variety of Sahelian soils and microclimates, land uses, levels of technology, land management standards and population pressures. Likewise, the use of economic indicators can give the wrong signals about the sustainability of development and environmental change (Benneh *et al.*, 1996; Reardon *et al.*, 1997) (see Chapter Two). Biophysical indicators, such as loss of vegetative cover, are also misleading and the data are not consistent. There are no simple or commonly agreed measures of degradation. As researchers uncover the complexities of dryland agricultural systems (see figure 1.1) the notion of progressive decline in agriculture is being challenged (Biot *et al.*, 1995).

Figure 1.1: The complexity of agricultural strategies and associated ecological processes (source: Reenberg, 1996; also see Krogh and Paarup-Lausen, 1997)



1.1.3 Resilience and diversity

Despite the certainty that there has been drought and economic crises, and the less certain fears of intensification and degradation, rural people remain in farming in Niger. There is survival in challenging circumstances and livelihood recovery following disaster. More people make their livelihoods in the Sahel, at greater populations and livestock densities, than before the droughts in the 1970s and 1980s. This has led to many counter-arguments to the 'agricultural crisis' and less negative perceptions of intensification (Mortimore, 1998; Scoones, 2000). Farmers develop coping mechanisms, and adapt to changing situations (Tiffen and Mortimore, 1992; Tiffen *et al.*, 1994; Davies, 1996; Mortimore, 1998; Howorth and O'Keefe, 1999; Scoones, 1995; Adams and Mortimore, 1997; Mortimore and Adams, 2001). Research on the role of agricultural intensification and the local economy (Carswell, 1998; Mazzucato and Niemeijer, 2000), investment and conservation (Mortimore, 1989; Mortimore and Tiffen, 1996; Mortimore, 1998), woodland management (Yamba, 1993; Leach and Fairhead, 1988; 1995; Ribot, 1998; 1999) and diversification (Ellis, 1998; 2000; Rain, 1999) have all shown resilience in farming systems. Clearly a conversion of bush to farmland does not always entail lost productivity (Mortimore *et* *al.*, 1999). All these researchers have found little evidence for the belief that resource degradation is necessarily linked to high levels of population or to poverty, (issues discussed in more detail in Chapter Two). More important, the linkages between these variables are unlikely to be simple.

As a result of these investigations, understanding of the relationships between farm management and degradation has had to be reworked. The ecosystem would be better described as unstable but resilient, or in a state of disequilibrium, and farmers as risk managers and reflexive agents of change. Case studies are now focusing on capabilities, adaptability, flexibility and sustainability and they suggest that rural people themselves play a more important role than 'crisis narrative' assumes (Mortimore, 1989; 1998; Netting, 1993; Scoones, 1995; 1998; Howorth and O'Keefe, 1999; Singh, 1999). Greater emphasis is now placed on the engagement of local community institutions, participation of stakeholders, flexibility in interventions and provision of an enabling environment that provides market-driven incentives for change (Böjo, 1996; Böjo and Chee, 1997; Chambers, 1997) (see Chapter Two). Followers of Boserup (1965; 1972; 1981) argue that intensification develops naturally when people are under pressure. Sterk and Haigis (1998) also argued that only with social conflict, low 'entitlement exchange' and access to resources does human agency cause environmental degradation in Niger, and possibly elsewhere in Africa. The idea of 'entitlements' demonstrates that the process of land degradation is a continual negotiation between culture and land (see Chapter Two, section 2.3.1, for a detailed discussion on endowments, capitals and entitlements).

Such a re-evaluation raises the question of how rural dwellers use their skills in transforming their environment? Furthermore, soil fertility decline is no longer merely seen as a process of nutrient mining, nor erosion as leading to an inevitable loss of soil material and nutrients. Erosion cannot be treated in isolation from other aspects of soil management. Nevertheless, most theories on degradation have failed to take these dynamic aspects of resource management and investment into account. They have also failed to include the linkages between rural communities and changing markets, national laws, infrastructure, international aid and development (Snrech *et al.*, 1994). Understanding soil management involves a wider political economy and a plethora of non-technical issues (Swift, 1999). Although rural households place the greatest importance on subsistence, livelihoods also include non-agricultural components, such as migratory (short-term and permanent) and exchange systems. Thus market prices, the terms of trade, the structure of agrarian society, international economic relations, competing political interests and global politics become parts of the complex explanation of what smallholders actually do. An understanding of the constraints inherent in soil degradation and low soil fertility depends on an understanding of the behaviour of farmers through the agricultural growing season and the livelihood choices that they make about soil fertility management (Richards, 1989; Ramisch, 1998; Mortimore, 1998) (discussed in more detail in Chapter Two).

To understand these many choices there has been a growing recognition of the importance of studying diversity. There is a multiplicity of situations and complex interactions between society and nature, making generalisations inappropriate (Raynaut, 1997; Koechlin, 1997). Socio-environmental variability, even within Niger, creates great variety in agricultural practice. At the micro-scale, diversity in the ecosystems is matched by diversity in agricultural practice and this in turn is linked to diversity among households (Piters, 1995). Case studies make an important contribution to understanding these issues (Netting, 1993; Scoones, 1997; Mortimore and Adams, 1999) yet the interactions demand a closer engagement than many studies have so far achieved.

1.2 Significance of present study

This study examines livelihood strategies and soil fertility management in Fandou Béri in south-western Niger. The hinterland zone of the capital, Niamey, where the village is situated, could be seen as an inappropriate focus for ethnographic research or investigations into livelihood strategies because of the effect of urban-rural relationships. However, these hinterlands are large in West Africa (Snrech *et al.*, 1994) and understanding farmers' perceptions of farm management in these zones is necessary to explain changes in an area that is experiencing land use intensification and supplying its natural and labour resources to the city (Tacoli, 1998).

There has been little examination of land use and livelihood dynamics in the village, although the SERIDA project (see Chapter Three) began to investigate some of these issues, it did not specifically explore farmers' land allocation decisions or their choices for farm investment based on the resources within their household's livelihood structure. Understanding the choices and constraints in soil fertility investment is of particular interest because of the limited means of improvement in subsistence farming systems. For example, both Richards (1990) and Thompson (1993) stressed the inadequate understanding of knowledge, practice and process in fallowing, which is a particular focus of this study.

Moreover, Agrawal (1995) expressed concern over the continuing dichotomy between agricultural science and studies of farming experience. Land-use and investment changes are initiated by decisions at the farm-level, which are very often rooted in local perceptions of the quality of the natural resource base (Mortimore, 1995). Natural resources are socially constructed out of the knowledge and capabilities. In addition, management of natural capital resources cannot be divorced from economy or culture (Reenberg, 1996). Therefore, this study attempts to analyse the farming systems in Fandou Béri using a more holistic approach, grounded in local perception and livelihood structure. The study views farming as just one part of rural livelihoods, where decisions and investments in soil fertility, in terms of choices, capabilities and opportunities are based on households' resources. There is a need to understand farmers' perspectives of the value of soil fertility investment within their whole livelihood structure and to understand their decisions to invest. Influences on households' resources operate at a variety of scales and the study recognises that there is a wider framework of influences beyond the local.

In addition, this study recognises the need to understand soil fertility through research that treats farmers' livelihood strategies as differentiated, complex and realistic. Understanding strategies of different actors in soil fertility management is essential to understand poverty. Thus the study seeks to understand day-to-day farming decisions in the household; the importance of the rainfall on these decisions; how households manage their endowments of resources; what are their biggest challenges and constraints; and the important resources in access and transfers between endowments.

In examining these complex issues in a case study, the study hopes to make a contribution to the wider debate on sustainable rural livelihoods.

1.3 Study objectives and hypotheses

The broad objective of the study is to examine the relationship between rural dwellers' livelihoods and soil fertility in Fandou Béri, south-western Niger. The study has the following specific objectives:

- To develop detailed case studies to understand choices, perceptions and practice of Djerma and Fulani farmers.
  - How is indigenous knowledge used to manage soil fertility?
  - What do farmers consider soil fertility to be?
  - What is the role of micro-variability in farmers soil management and strategies?
  - How important is fallow in soil maintenance?
  - How has soil fertility changed?
  - What are the relationships between scientific and local geographies of natural resource management?
- To understand farmers' prioritisation of 'capital' assets for natural resource management through the agricultural calendar.
  - What are the most important determinants of land allocation?
  - What is the relative importance of soil fertility (natural capital) as against other 'capitals' (e.g. human, social, financial, physical and other natural capitals)?
- To understand diversity in natural resource investment[1] and land allocation between households based on endowment of 'capitals'.
  - Are there groups of differentiated strategies?
  - How does varying access to 'capitals' affect investment and land allocation?
  - Do particular social groups or actors have access to particular clusters of 'capitals'?

[1] Investment in the farm is used to refer to the input of all the different 'capitals' available to the household (i.e. not just cash-based transfers).

- Which combination of 'capitals' is important for farm investment and can 'capitals' be substituted for each other?
- Is diversity expressed spatially in management zones?

- To understand how the non-agricultural component of rural livelihoods influences investment in natural capital.
  - How is the availability of 'capitals' influenced by socio-economic policy beyond farmers' control (e.g. land tenure law, governance, privatisation and macro-economic policy)?
  - What are the relationships between coping strategies (i.e. diversification) and soil fertility management?
  - What trade-offs confront particular social groups in deciding upon a certain strategy of farm investment and by what rules, organisations and power relations are they determined?
  - How do the management strategies in Fandou Béri compare to other villages in the region by previous studies?

Hypotheses to be tested:

The research uses the following working hypotheses concerning the issues related to the objectives indicated above:

- The key determinant of land allocation and level of soil investment by farmers is the perceived soil fertility in much of the agro-scientific literature. It also indicates that the key reason for fallowing land is poor soil fertility.
- Distance from the household, land-use type and soil fertility are most important in determining spatial patterns of land management/investment in the village.
- Each farmer's prioritisation for natural resource investment is based on their perceived structure of the household's 'capital' assets and their individual capability (i.e. entitlement analysis).
- Choice, 'capitals' and prioritisation differ between Djerma and Fulani farmers.
- Land-use type and socio-economics differentiate household strategy into further groups. Unequal opportunities for soil fertility maintenance result. Households that are large, wealthy or socially important are more successful in maintaining soil fertility because they have more choices and are better able to access

'capitals'. For these households, the key constraints to production and the key determinants for land allocation are labour or cash shortages (soil fertility is maintained). These farmers are able to trade-off soil fertility decline with household economic maintenance through livelihood diversification. In contrast, small households that are poor have fewer choices. Their key constraint to production, and also their key determinant to land allocation, is soil fertility.

- For wealthy households, livestock is the key influence on farm investment and 'capital' substitution. There are flows from financial and human 'capitals' to natural 'capital'. For poorer households, investment in social capital is important to livelihood maintenance. Livelihood diversification plays an important role for all households' livelihood maintenance.
- Drought lowers the value of natural capitals, while access to financial and social capitals are influenced by the wider framework of transforming structures and processes, which in turn influences investment in natural capital.

1.4 Structure of the study

The study is organised into two parts. Part One presents the study's approach to theory and methods. Chapter Two reviews different approaches to intensified farming in the West African Sahel. The main discourses in the literature on agricultural sustainability, approaches to soil fertility management and the development of agroecological thought are discussed. Definitions of terms used in the study are provided. The methodological approaches and framework used in the study design are outlined in Chapter Three.

Part Two views farming as a component within rural Sahelian livelihoods. Chapter Four introduces the study village and describes the farming system. The study results are discussed in Chapters Five to Seven, scaling up from intra-household analysis, through inter-household diversity to influences at the larger scale, to build an understanding of rural livelihoods in Fandou Béri. Chapter Five examines personal narratives, using extracts from ethnographic case studies. The chapter discusses the dynamic process of choice and prioritisation through the agricultural calendar, but particularly through the rainy season. Farmers' perceptions of choice, based on their 'capital' resources (using a 'Sustainable Livelihoods' framework), are analysed in terms of perceptions of access, entitlement, capability and constraint. Farmers' perceptions of change in farmland and soil fertility and their local knowledge in managing soil fertility are presented and compared throughout to the scientific evidence. Chapter Six analyses the diversity in farmers' land management practice, based on their household 'capital' endowments. These analyses include the statistical patterns between strategies, determinants of land allocation, constraints to soil fertility improvement and spatial patterns of diversity. Case study examples of differentiated strategies and models of farming investment and land allocation are presented. Chapter Seven presents the wider framework of linkages in rural livelihoods. These influences are usually beyond the direct control of rural dwellers in Fandou Béri but have an important impact on their agriculture and livelihoods. The chapter also focuses on aspects of tenure and diversification.

Chapter Eight reflects on theoretical and practical areas of the thesis, including the Sustainable Livelihoods framework and the fieldwork sample. Chapter Nine contextualises the study findings within research from other dryland African villages; attempts to draw conclusions to the initial questions from the evidence at Fandou Béri; and indicates further research requirements through a discussion of the points of weakness and strength in achieving sustainability at Fandou Béri.

PART I
Approach to Theory and Methods

2
Reviewing approaches to intensified farming in the West African Sahel

This chapter reviews approaches to the intensification and sustainability of farming in West Africa, to locate this study within the theory. It begins by clarifying the meaning of some concepts that are referred to throughout the study. Section 2.2 highlights the complexity of the relationship between degradation and intensification by reviewing the arguments for soil fertility maintenance and improvement, its relationship to food production in the Sahel, the different concepts of sustainable agriculture and the resulting approaches. In section 2.2.4, the ecology of soil fertility is introduced and the theory on nutrient budgets, flows and cycling are outlined. Section 2.3 presents a brief review of the theory on perceptions of smallholder coping strategies in dryland rural Africa. The development of agroecological thought, indigenous soil fertility management and the problems of risk and uncertainty are each reviewed in turn.

2.1 Definition of conceptual terms

Some concepts are referred to throughout the study. This section clarifies the meaning of following terms: natural resources, soil fertility, soil productivity, nutrient capital, micro-variability, soil degradation, land degradation, indigenous knowledge and sustainable livelihoods. Other concepts, such as sustainability and entitlements are discussed later in the chapter.

Natural resources

The natural resource endowment of a household is the productive capacity of the soil and other living resources to which members of the household enjoy rights of access, both to work and to enjoy the benefits. Such endowments are variable socially, in time and in space. Access to an endowment (the resulting 'entitlement') is critical (for further discussion see section 2.3.1; Gasper, 1993; Leach *et al.*, 1997; Scoones, 1998; Leach *et al.*, 1999).

Soil fertility

The agronomic literature generally acknowledges that soil fertility is related to productivity and nutrient capital. The fertility of the soil, while often related solely to nutrient status, can be broadly defined as the ability of the land to produce and reproduce; its capacity to support plant growth over time (Ingram, 1990), under given conditions of climate and other relevant properties of the land (Young, 1989). The inherent soil fertility can be divided into 'physical fertility' (the provision of moisture and air) and 'chemical fertility' (the provision of nutrients) (van Reuler and Prins, 1993).

Thus 'soil fertility' is a complex concept with many components (chemical, biological and physical properties). Agronomic indicators of soil fertility include organic matter content, micro-organic activity, soil air and water supply and quality (as related to soil depth, texture and structure), water balance and the availability of the most important nutrients (Finck, 1995). Sixteen chemical elements are considered essential to plant growth (Eyasu, 1997), three of which (carbon, hydrogen and oxygen) are elements obtained from air and water. The primary nutrients that are required by plants in relatively large quantities are nitrogen (N), phosphorus (P) and potassium (K). Calcium (Ca), magnesium (Mg) and sulphur (S) are considered secondary nutrients, because they are required by plants in smaller quantities and only infrequently deficient (Kelley and Stevenson, 1995). There are seven other nutrients (iron, boron, zinc, copper, manganese, molybdenum and chlorine) known as micro-nutrients because they are required by plants in very small quantities (Batey *et al.*, 1997).

Soil fertility decline is associated with negative nutrient budgets (Scoones and Toulmin, 1999b) or a reduction in the availability of major nutrients. It is also associated with a loss of water holding capacity, which is commonly caused by erosion.

Soil productivity

The 'productivity of the soil' is a composite term that describes the overall productive potential of a soil arising from all aspects of its quality and status, such as its physical and structural condition as well as its chemical content (Lal, 1990). It is usually measured in terms of output or harvest, in relation to inputs, for a specific kind of soil under a defined system of management. Conceptually, 'productivity' is close to 'sustainability' in representing the intrinsic quality of the soil resource. However, it should not be confused with production, the actual output (e.g. biomass or crop yield), which is affected not only by the resource quality but also by applications of technology, such as fertilisers, improved seed varieties, irrigation, or green manures.

Nutrient capital

Nutrient capital can be defined as the stock of nitrogen, phosphorus and other essential elements that can become available to plants (Sanchez *et al.*, 1996). Soils vary widely in their initial levels of nutrient capital, but all suffer depletion of that capital when brought into cultivation, after which nutrients are removed in crops or lost through leaching, erosion, etc. Sandy soils, common throughout the drylands, are especially prone to this problem (Buresh and Smithson, 1997). A poor nutrient stock does not necessarily mean that the soil will not sustain production as this depends also on the long-term resilience of the system. Penning de Vries and Djitèye (1992) concluded that nutrients were limiting in much of the Sahelian agricultural zone, in areas with average annual rainfall of more than 250mm. Nevertheless, the nutrient stocks in individual plots within farms and village territories can differ considerably from the average, depending on differences in soil texture, land-use histories, rainfall variability and the individual capabilities of the farmers involved. Efficient nutrient management means maintaining the soil nutrient capital (Smaling and Braun, 1996).

The main sources of plant-available phosphorus, which is generally the limiting nutrient in the Sahel (Bationo and Mokwunye, 1991), are the weathering of soil minerals, the mineralisation of soil organic matter, fertiliser applications and organic inputs. Unlike nitrogen (N), phosphorus (P) is not biologically fixed from the air and the level of available P is highly affected by the level of P-fixation, making P a potentially serious constraint (Mahamane *et al.*, 1996). If there is low or erratic rainfall, despite poor soils, soil N may not be the limiting factor. Crop response to N is usually proportionally greater as rainfall increases, whereas responses to P are proportionally greater with rainfall decreases because rainfall is a key variable for P-release (Gregory *et al.*, 1997).

The sources of nitrogen are the mineralisation of soil organic nitrogen pools, nitrogen fertilisers, and the decomposition of organic inputs such as plant biomass and animal manures. Biological nitrogen fixation becomes an input when the leaves of nitrogen-fixing species, that have been added to the soil, begin to decompose. Nitrogen availability is less influenced by the available stock and degree of mobilisation and more by the rate of nitrogen cycling and the balance between N and other nutrients. In sandy soils, where organic matter is limited, a more intermittent cycling or pulse-event is evident (Brouwer and Powell, 1997a). This cyclic peak is linked to the beginning of the rainy season and the level of clay content in the soil, and the release the result of a rapid increase in the rate of mineralisation. Where there is little microbial activity and the structural protective capacity for soil is poor, opportunities for the build up of N-capital (often associated with organic matter) are limited. However, for some, as yet unknown reason, considerably more organic N can be mineralised in a sequence of wet-dry cycles than if the soil was kept permanently moist (Brouwer and Powell, 1997a).

Micro-variability

Many development projects have been frustrated by naturally high spatial variability of soil characteristics and the resultant marked disparity in crop growth and establishment (Manu *et al.*, 1996). From an ecological viewpoint, spatial heterogeneity in distribution may be of considerable importance as it plays an important role in niche formation, a prerequisite for genetic diversity within and between natural populations (Grubb, 1977). Buerkert *et al.*, (1995) described the micro-variability exhibited by irregular stands of plants and the variations in above-ground dry-matter over short distances, at a site close to Fandou Béri. The causes are still under investigation but include termite activity, small differences in nutrient availability, soil texture, land use history, micro-topography, trapping of aeolian dust by bushes, crust formation by nitrogen-fixing algae and the nitrogen fixing abilities of specific plant species (Geiger *et al.* 1992; Drees *et al.*, 1993; Krogh, 1995a; Davis *et al.*, 1995; Fog and Krogh, 1996; Brouwer and Bouma, 1997; Dakora and Keya, 1997;

Piper, 1998). Many farmers have learned to exploit these variations and many see micro-variability as a farming opportunity (Reenberg and Paarup-Laursen, 1996).

Land degradation

Land degradation is an important phrase in this discussion because it is used in so many contexts and because it is integral to understanding changes in soil fertility. Land degradation is a composite term signifying the temporary or permanent decline in the productive capacity of the land (Blaikie and Brookfield, 1987). It is the aggregate diminution of the productive potential of the land under arable agriculture, rangeland or forestry (CCD, 1997). The concept defies easy quantification because it consists of many interrelated processes (Manu *et al.*, 1996). It is a concept of linear change with an elusive reference point and, in terms of vegetation change, there are contradicting measurements. The FAO identified desertification as being the extreme result of widespread land degradation and many still see desertification and degradation as the same (e.g. Amissah-Arthur *et al.*, 2000). However, land degradation is more than a physical or environmental process; degradation is a social problem, with economic costs attached, as it consumes the products of labour and capital inputs (Enters, 1997). The application of the term is also relative; levels of acceptability are related to individually determined standards (de Groot, 1992). For example, a decline in biological productivity may be accompanied by an increase in economic productivity. Thus local perceptions of degradation will reflect local livelihood strategies.

Soil degradation

Lal (1990) drew attention to the confusion that often arises in the agroecological and development literature over the terms 'soil degradation', 'land degradation', 'soil erosion' and 'soil depletion'. Soil degradation is a form of land degradation. For Lal, soil degradation is defined as a decrease in soil quality as measured by changes in soil properties and processes, and the consequent decline in productivity, in terms of immediate and future production. The FAO (1980) defined the concept as the deterioration or total loss of the productive capacity of the soils for present and future use. Some researchers (Lal, 1990; Oldeman *et al.*, 1990) refer such losses to the various processes of erosion (by wind and water) and of chemical and physical depletion (loss of soil nutrients or fertility). Soil degradation is difficult to measure given that productivity is affected by changes in water-availability, agricultural and range management practices, labour input, technology and crop selection. Therefore, any variable (e.g. crop yield) can only serve as a proxy indicator.

Soil erosion

Soil erosion is one of the main processes of degradation and consists of the physical detachment of soil particles by wind and water and their transport to other parts of the landscape, to rivers or to the sea. 'Soil erosion' is a term often used to refer to a loss in soil productivity due to physical loss of topsoil, reduction in rooting depth, removal of plant nutrients, and loss of water holding capacity. The rate of erosion is determined by the interaction of a number of factors, including climatic erosivity, soil erodibility, and the local management. Soil erodibility has a number of determinants, including soil type, the local management of the surface layer (which may allow the soil to crust), and an increase in bulk density or a decrease in organic matter. Topographic factors such as slope steepness, length and shape also influence erodibility. The amount, intensity and seasonality of rainfall and windspeeds, and vegetative cover are the important factors. These factors have been used in predictive equations by numerous researchers (e.g. Chappell, 1995; 1998; Mulengera and Payton, 1999; Jain and Kothyari, 2000; Tiwari *et al.*, 2000). Society is concerned with soil erosion primarily because of its contribution to longer-term soil degradation and because it impairs sustainable productivity of the land (Stocking, 1992; Mahendrarajah and Warr, 1993; Eaton, 1998).

Soil depletion

'Soil depletion' is 'the loss or decline of soil fertility due to the removal of nutrients by crops or the removal of nutrients by water passing through the soil profile (Lal, 1990:9). The depletion process is less drastic than soil erosion and can be more easily remedied through cultural practices, such as adding appropriate soil amendments and managing crop residues. Long-term monitoring studies (Pichot *et al.*, 1981; Pieri, 1989; Lal, 1995) provide the best sources of evidence of soil fertility decline.

Indigenous and local knowledge

Indigenous knowledge (IK) is knowledge that is unique to a culture or society. It is passed down through generations and is adapted to solve local problems and goals. While IK is intertwined with the belief and value systems that underlie a culture, it remains dynamic and inclusive (Pawluk *et al.*, 1992; Chambers, 1997) (see section 2.3.2). A recent paradigm shift has occurred in the study of dryland agriculture such that the need to listen and learn from IK is now stressed (Brokensha *et al.*, 1980; Warren *et al.*, 1995; Chambers, 1997; Winklerprins, 1999; Prain *et al.*, 1999). Knowledge is viewed as a social process, and knowledge systems are seen in terms of the multiplicity of actors and networks through which information travels (Brokensha *et al.*, 1980; Warren *et al.*, 1995). The guiding phrase has been 'the analysis of difference' which suggests that IK is multi-layered, fragmentary and diffuse and rarely systemised. For these reasons this study refers to this type of knowledge as 'local' or 'farmers' knowledge' because 'indigenous' suggests that IK has been developed without outside influences (Barrera-Bassols and Zinck, 2000).

Sustainable livelihoods

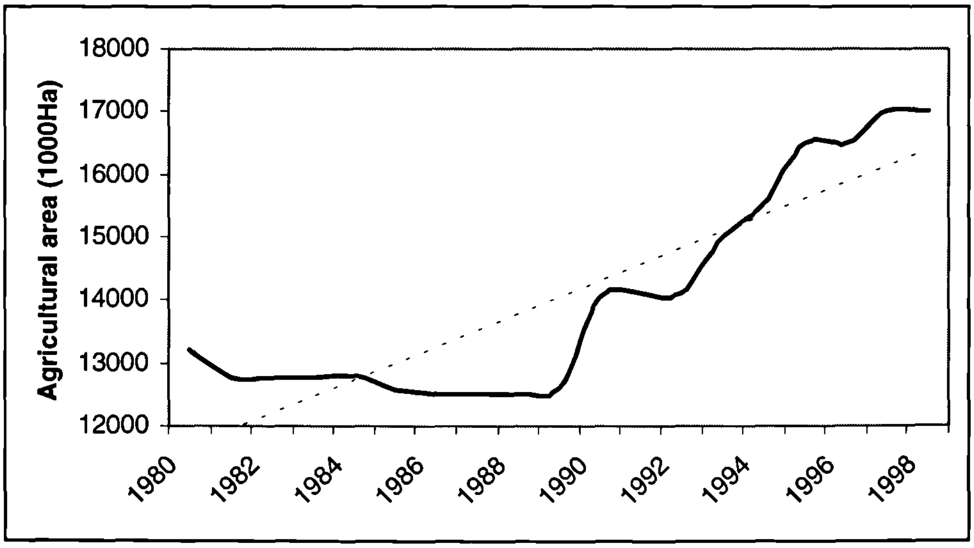
Internal debates in Oxfam in 1993 and 1994 led to the definition of a 'livelihood' as 'a means of living, not just of production' (Oxfam, 1994). Further definition was developed by Chambers and Conway and has now been widely used (Chambers, 1988; Scoones, 1998; Hussein and Nelson, 1997; Carney, 1998). Chambers and Conway (1992) defined a 'livelihood' as 'the capabilities, assets (including both material and social resources) and activities required for a means of living'. A 'livelihood' can be defined as 'sustainable' when it can cope with, and recover from, stresses and shocks and maintain or enhance a household's capabilities and assets both now and in the future, while not undermining the natural resource base (Leach *et al.*, 1997; Scoones, 1998; Carney, 1998). Other views of sustainability are discussed in section 2.2.2. The concept of a sustainable livelihood has been developed into working frameworks that include understanding use of the local asset base in relation to different forms of capital linked to livelihoods (natural, physical, financial, social and human). A more detailed description of this framework is given in Chapter Three (section 3.3).

2.2 Soil fertility management and sustainable agriculture

2.2.1 Soil fertility depletion and the food crisis debate

There are fears that while shifting cultivation has proved an effective form of food production, the system has traditionally been extensive and this extensivity may no longer be possible (Reenberg and Fog, 1995; Mwangi, 1997). Patterns of land expansion and intensification of farming in the Sahel were identified by Snrech (1994), Stroonsnijder (1994) and Barbier (2000). These patterns, together with population growth and variable rainfall have lead to a debate about whether food production will decline and whether the present deficit will ever be made up (Hjort af Ornäs, 1992; William, 1998; Parry *et al.*, 1999). Figure 2.1 shows the recent expansion in agricultural land in Niger.

Figure 2.1: Expansion in agricultural area in Niger 1980-1998 *(source: FAOSTAT, 2001)*



The crisis is often represented in terms of negative feedback loops in an equilibrial system, disturbed by 'external factors', such as the growth of human or animal populations, drought or the market. The most important feedback for neo-classical economic analysts is population growth; for socialist analysts it is the market; while technical analysts emphasise the importance of bioproductivity constraints. Gupta and Asher (1998) argued that land degradation reduces the productivity of people and natural resources, with a potentially adverse effect on food security and the provision of other basic necessities, that could lead to inflation. In a report in 1988, UNEP also presented the opinion that land and soil degradation could result in human and environmental disasters and that cropland and rangeland in the Sahelian drylands were under great threats. These projections of population growth and increased soil mining are based on the Malthusian model, but simplistic neo-Malthusianism should be rejected because the notion that land has a fixed carrying capacity (to maintain people's food production and supply) denies the potential of technological development. Even analyses of Sahelian economics do not indicate repeated crisis. Markets indeed are predicted to increase (e.g. OECD, 1995, Club du Sahel's West Africa Long-Term Perspective Study 'WALTPS').

Boserup (1972; 1981) challenged Malthusian theories by developing the hypothesis that population increase actually prompts the development of technology. Farmers exploit diversity by choosing amongst cultivars, technologies and strategic options to the limit of their resource endowments (Pingali and Binswanger, 1988). Flexibility also helps farmers cope with other unstable and unpredictable factors of production, such as climate (Washington and Downing, 1999). Population growth and innovation has lead to documented cases of induced intensification and growth in production (Hayami and Ruttan, 1985; Tiffen and Mortimore, 1992; Turner *et al.*, 1993; Meertens *et al.*, 1996). In this model, more productive management systems develop from within the existing system and moreover, population growth and monetisation are essential elements in this form of intensification.

However, it is simplistic to say that crisis prompts people to innovate and survive (Stone and Downum, 1999). Each case is specific. The model assumes that labour is directed into the farm and that there is an 'efficient' market system (based on neo-classical economic principles) (Hayami and Ruttan, 1985; Murton, 1999). Pressures on resources from increasing demand may equally result in a downward spiral and the effects are socially differentiated. Furthermore, the market economy cannot be presumed to be the dominant institution guiding allocative decisions.

Both the Malthusian and the Boserupian models are oversimplifications. Development in a specific place is dependent on complex relationships, individual capabilities and knowledge, access to other resources, labour availability, market prices for produce, social organisation and informal institutions, and the role of the state. In terms of balancing food security and resource utilisation, ecological and economic linkages are multiple and complex (Sanchez and Leakey, 1997). Furthermore, any path to a 'modern market economy', may not result in conflict between informal institutions[1] and household productivity objectives (Berry, 1989; Reardon and Vosti, 1995). While informal institutions require investments they often provide little visible promotion and assistance for agricultural performance and the use of technologies, through networks, kinship ties and inter-household relationships (Richards, 1985; Guyer, 1992; 1997). Economic systems based on capital and mutual assistance operate simultaneously.

Thus food security is not a question of production and supply but is dependent on people's 'exchange entitlements' (Sen, 1981; Drèze *et al.*, 1995; Anard and Sen, 1997; Moore Lappé, 1998). The food debate and the environmental debate are linked by being dominated by the quantity of natural resources available or accessibility through cash, while entitlement theory (see section 2.3.1) focuses on access to all types of resources. For example, the rural poor are often dependent on home production for their food security, which in turn depends on their exchange entitlements to land for cultivation (and therefore the quality of land and land-tenure relationships), and capital for investment in nutrient inputs, infrastructure and labour (including the potential to work and the knowledge of farming techniques).

2.2.2 Sustainable agriculture

Defining 'sustainable agriculture' is not easy (Lélé, 1991). Sustainability in a production system can been divided into 'ecological' sustainability (maintaining or enhancing biodiversity), 'economic' sustainability (maintaining or enhancing economic profitability) and 'social' sustainability (equity in the enjoyment of these benefits, both among the present generation and between present and future generations) (Munasinghe, 1993; Mortimore and Adams, 1999). The FAO definition (1989) is widely quoted in the literature. It states that sustainable agriculture involves the successful management of the resources for agriculture to satisfy human needs,

[1] Informal institutions are taken to include local organisations but also social norms, kin networks, customary law, rules etc. that guide people's behaviour and resource allocation within a society.

while maintaining or enhancing the quality of the environment and conserving natural resources. These statements indicate the importance of all resources within the livelihood structure to sustainable agriculture. In response to environmental concerns, a range of techniques and approaches have been promoted by international institutions and programmes, such as the FAO, UNDP and Agenda 21 (at UNCED), and NGOs (Altieri, 1987; Reijntjes *et al.*, 1992; Pretty, 1995; Conway, 1997; Shepherd, 1998). These authorities agree that sustainable agriculture requires the inclusion of the following aspects (Neefjes, 2000):

- Research and development of technologies that maximise local resources (inputs), improve soils, reduce pollution and health risks, etc. (Examples of such techniques are crop rotation, integrated pest management, green manuring, agro-forestry, alley cropping and intercropping, diversification of crops, and locally improved varieties).
- Participation of men and women farmers in technology development and technology adaptation, leading to technologies that are particularly relevant to poorer farmers.
- A gender-sensitive approach to technology development and extension (for example, responding to the need of women farmers or livestock keepers to combine food production with daily tasks).
- Improved land-tenure security achieved through empowerment by land rights. The Brundtland Report called for secure land rights. Blaikie and Brookfield (1987) argued that land managers can be expected to manage land better only if they see benefits now and in the future from doing things differently. Tenure issues have been a popular form of incentive to investment (Gray, 1997; Lund, 1998; 2000; Place and Dewees, 1999; Bryceson *et al.*, 2000), but not always to the desired effect (Winters and Quan, 1998) (these issues are discussed in Chapter Seven).
- Decentralisation of research and extension services (Winter, 1998).
- Improved infrastructure related to financial services, processing, and marketing.
- Promotion of agroecological systems that combine livestock, crops, and sometimes forestry and fish farming.
- National and international pricing and market policies that stimulate local production and product diversification.

The soil is crucial to the achievement of sustainable agriculture because it contains a very important part of the means for crop growth (Marschner *et al.*, 1997; Syers, 1997). The manner in which soils are managed has a major impact on productivity and sustainability (Reardon, 1995). Much concern has been raised over the low and declining nutrient capital and the resulting loss of soil fertility in the Sahel (Stoorvogel and Smaling, 1990). Pieri and Steiner (1997) claimed that no agricultural system could be considered sustainable unless it ensured maintenance or improvement of soil fertility. Soil fertility is a prominent indicator of sustainable agriculture and is a potential criterion for quantitative assessment (Smaling, 1993; Reardon, 1995).

While most definitions of 'sustainable agriculture' refer to the capacity of the land to remain productive and the maintenance of the resource base, 'agricultural sustainability' remains part of the wider concept of 'sustainable development', which is an equally difficult concept to define (Redcliff and Sage, 1994; Prugh *et al.*, 2000). The Brundtland Commission defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). Most definitions agree that it is the maintenance of total 'capital' stocks over time, and that any given social and environmental system can be seen as the sum of different types of capital (human, social, natural, economic, physical or human-made) (Daly, 1992; Castillo, 1992; Serageldin, 1996; 1999; Scoones, 1998; Carney, 1998; Neumayer, 1999; Ashley and Carney, 1999; Neefjes, 2000; Warren *et al.*, 2001; submitted). Both concepts raise many questions: what place does natural capital have in theories of sustainable development; how much natural capital should be conserved; can natural resources be substituted within the agricultural system; how does natural capital fit in with theories of livelihood coping strategies?

Pearce *et al.* (1989) offered a choice between what others have called 'weak' and 'strong' sustainability: the former is about the next generation inheriting a total stock of wealth (natural and human-made assets) that is equal to or better than the current one; the latter is about the next generation inheriting an equal or better stock of natural assets. The central issue in choosing between these extremes is whether natural and human-made assets can be seen as substitutable. For example, the loss of topsoil could be substituted with high and sustained food production using non-natural inputs, or alternative livelihoods. Substitution implies it that sustainability is based on economics, whereas no allowance for substitution implies that valuation of transfers is not practical.

If sustainable development in agriculture is taken to mean no reduction in natural capital (i.e. the 'strong sustainability' view), one accepts the irreversibility and non-substitutability of some assets, the uncertainties and risks involved in environmental change, and the fact that technological development cannot be fully predicted nor be expected to solve all problems (Eswaran *et al.*, 1997). The achievement of strong sustainability, perceived as the maintenance of welfare (i.e. maintaining total utility) is ultimately possible only if what cannot be substituted or created is protected: of the different forms of capital only natural capital cannot be created by people, and it is natural capital therefore that must be protected. Neefjes (2000) reasoned that environmental-resource sustainability was essential for intergenerational equity in a strong sustainability argument. Even stronger sustainability might require the sustaining of aspects of the environment that cannot be considered as material resources for human utility, but which have a spiritual or political value (Jeans, 1999). This 'green' position argues that there is an inherent value to nature (see Trainer, 1995 and discussion in Neumayer, 1999). In this format neither a reduction in poverty nor economic growth is realistically achievable.

Maintaining natural capital is particularly important for people who live on the edge of survival, and who depend on resources from their immediate environments (Benneh *et al.*, 1996). However, poor people have little capacity to forgo consumption and need to substitute natural capital for other assets; in other words they cannot easily aim to pass on natural wealth to the next generation and thus hand over an equal standard of consumption and survival (Neefjes, 2000). Some researchers have questioned the strong sustainability position, claiming that it makes a negative assumption about the influence of people; Harris (2000) asked whether smallholders in the Sahel have achieved their production by 'mining' soil nutrients (natural capital), or by sustainable recycling and active management of soil fertility. Farmers often see soils brought into production through years of farming and soil management.

At the other extreme, 'weak' sustainability allows for the conversion of natural capital into human-made capital, provided that the total stocks are maintained. Proponents of weak sustainability maintain that both human-made and natural capitals are substitutable in the long-term. This approach sees substitution into economic growth as important, for example through livelihood diversification.

A third category was offered in the framework by Serageldin (1996; 1999) at the World Bank: 'sensible' sustainability refers to a situation in which there is the maintenance of a level of 'critical natural capital', allowing the conversion of the remaining natural capital to other forms. This approach was first used by Pearce *et al.* (1989) to argue that the sustainability of economic systems is their ability to maintain productivity under stress; the conservation of natural capital leads to increased resilience of economic systems, because it provides a flow of services to the economic system. They argued that some natural resources, including soils, are 'critical capital' to the system and therefore should be conserved.

Nevertheless, any practical theory of 'sustainable agriculture' must be consistent with the farmer's objectives of productivity and security. Farmers have an intimate knowledge of how to optimise the system and use its natural diversity as part of their livelihood strategy (Altieri, 1987; Mortimore, 1998). Chambers (1983) argued that, for these reasons, it is the plight of the poor that should set the agenda, and in his approach to sustainability he directed attention to the concept of 'sustainable rural livelihoods', where agriculture is seen within the structure of making a livelihood (see section 2.1 for the definition).

These many concepts of sustainable agriculture have filtered through into the world of development, where efforts have been made to operationalise some of the key concepts in development projects, national-level planning, and in international agreements (Booth, 1995; Scoones, 1998; Carney, 1998; Adams, 2001). There has been a reworking of thinking about what constitutes a 'sustainable' rural livelihood (Carney, 1998; Farrington *et al.*, 1999; Goldman *et al.*, 2000), where diverse activities are important. This is discussed further in sections 2.3.1 and in Chapter Three (section 3.3). Adams (1990) argued that ultimately 'sustainable development' is a process and not an end-point.

2.2.3 Approaches to soil fertility maintenance

Many strategies have been proposed by the research community to maintain and improve soil fertility and then to increase production (Ayoub, 1998). Not surprisingly all agency documents argue for some form of external intervention whereas international agricultural scientists argue for an important role for science. The solutions range from those who emphasise major efforts to recapitalise soils (Sanchez *et al.*, 1997; Breman and Sissoko, 2000), to a sustained use of inorganic fertilisers (McIntire and Powell, 1995; Kouyate *et al.*, 2000), integrated nutrient management and those who believe in a more efficient use of internal resources, with limited external inputs as a sustainable way of addressing the problem (Reijntjes *et al.*, 1995).

High external input agriculture

Belief in technological intensification underlies the reasoning behind arguments for capital-led intensification as the way to increase productivity for growing populations and maintain environmental sustainability (Breman, 1998; Breman, 2000). This approach to soil fertility maintenance and improvement is commonly associated with 'modern' economics, where labour is seen as a cost factor that should be minimised. Its primary aim is to improve economic growth. It depends on technological optimism (problems can be solved through science), leading to the view that labour can be replaced by capital-intensive technology and task specialisation. The proponents of this approach argue that increased inputs and technological innovation are needed to prevent further decline in soil fertility. The approach is based on the use of mineral fertilisers, hybrid genetically-modified (GM) seed and pesticides. It is still a key focus of research at international research institutes in Niger. Advocates of high input approaches to development have argued that only they are able to overcome the shortages that the farmers themselves complain of (Stoorvogel and Smaling, 1990; Bationo and Mokwunye, 1991; Bationo *et al.*, 1992; 1993; Larson and Frisvold, 1996; Sanchez *et al.*, 1997; Powell *et al.*, 1999; Baidu-Forson, 1999).

However, there are several problems with a 'high input' route to sustainability. For smallholders at least, it risks agricultural involution (Goodman and Watts, 1997). First, price is a fundamental constraint to 'high input' agriculture. Farmers lack the financial capital and basic institutions to sustain high inputs, and these deficiencies have been made worse by the removal of subsidies (Reardon *et al.*, 1997). Wealthy farmers may continue to use mineral fertilisers but only as low-input applications with precise timings and on crops with the genetic adaptation to respond. Second, the use of mineral fertiliser is a risky investment for any farmer. Yield response to mineral fertilisers is highly variable, depending on local soil conditions and rainfall patterns. Third, while GM plants may have short growing seasons, they require specific applications of mineral fertiliser and pesticide to be resistant to drought, disease and pests and need to be purchased each season. Their effect on local biodiversity is unknown (Tripp, 1999; 2001). Lastly, there are methodological challenges in discussing farm shortages with farmers because during initial questioning, they often give priority to problems believed to be solvable by outsiders (such as the problems of information, chemical fertiliser, seeds and assistance with transport) whereas problems believed to be locally resolvable (such as labour, organic inputs and cash shortages) only become evident on deeper acquaintance with each farmer. It is likely that the high input approach would sideline small family farms and reduce their market share because agro-industrial corporations depend on enormous economies of scale, high levels of capitalisation, and advanced technology and these are antithetical to the low-yielding, labour-intensive nature of smallholder farming in the Sahel (Hobsbawm, 1995).

Low external input sustainable agriculture (LEISA)

The development of low external input sustainable agriculture (LEISA) (or organic farming, conservation farming, permaculture, etc.) is dependent on the management of biodiversity (a form of natural capital). The approach aims to target poverty and long-term survival through strong environmental management. Advocates of LEISA argue that these principles can be applied by way of various labour-intensive techniques to provide sustainable production and resilience in 'conservation' farming (Klaij *et al.*, 1994; Kouyate *et al.*, 2000). Each technique is aimed to have an effect on productivity, security and continuity within the farm system. According to LEISA (see Reijntjes *et al.*, 1996) there are five ecological principles for the management of sustainable agroecosystems:

1. Securing favourable soil conditions for plant growth, particularly by managing organic matter and enhancing soil life;

2. Optimising nutrient availability and balancing nutrient flow, particularly by means of nutrient fixation, cycling and the complementary use of organic fertilisers;
3. Minimising nutrient losses by way of microclimate management, water management and erosion control;
4. Minimising losses due to plant and animal pests and diseases by means of prevention, safe treatment, and crop rotation. The efficiency of nutrient cycling and the stability of pests and diseases in the system depend on the amount and type of biodiversity as well as its structural diversity;
5. Exploiting complementarity and synergy in the use of genetic resources which involves a high degree of functional diversity.

It is a popular perception within this approach that smallholder shifting cultivation follows a singular path to an agroecological system that combines livestock with crops and organic farming methods (i.e. the 'mixed farming model') (see discussion in Sumberg, 1998; Wolmer, 1997; Wolmer and Scoones, 2000).

Despite the good intentions of 'low external input' approaches in respect to its targeting of poverty alleviation, it faces large impediments in rural communities. Intensive 'organic' practice, which is implied, is fundamentally at odds with livelihood practice or resource capabilities of most Sahelian smallholders because low external input's populist perspective assumes that knowledge is developed inside a closed 'community'. However, it requires high labour inputs that are often not available. While gaining much currency with the increasing interest in soil fertility processes, a model of mixed crop-livestock intensification ignores the issue of endowments, access and entitlements within the wider household livelihood structure or the possibility of complex trajectories of change (Ramisch, 1999b; Wolmer and Scoones, 2000). The assumptions ignore the spatiality of 'communities' and the role of diversification of rural livelihoods (i.e. it assumes that households will want to invest in farming) (Reenberg, 1996; Bryceson *et al.*, 2000). The nature of the livelihood system means that necessary growth cannot be found within the village and nor can returns from intensification be recycled into agriculture. 'Low external input' approaches are useful only if they are participatory and combine an understanding of constraints to precision farming that exist with appropriate technology (Gandah *et al.*, 2000). Furthermore, low external input agriculture relies on very little external input (off-farm resources) and places more emphasis on biological processes and nutrient cycling. This is not necessarily the same as sustainable agriculture and can even result in soil mining (Scholes *et al.*, 1994; Breman, 2000).

Appropriate Technology or Integrated Management

Many argue that the most successful approaches to change in subsistence farming are those of the Appropriate Technology (AT) movement and of 'Integrated Management'. These approaches enable the skills and experience of the 'outsider' to be combined with the skills, experience and needs of the 'insider' (small-scale producer). The aim is to combine the strengths of the insiders and outsiders in an effective way, that is genuinely participative, and creates a capacity to manage the processes of technical change in the future, and is not just in a single one-off event (King and McGrath, 1999).

'Indigenisation' in the AT approach refers to the incorporation by people of externally derived technology and other resources in to their own culture. In the African context, it has been argued that 'something is indigenous if it is an authentic expression or outcome of Africa's history, social evolution or culture' (Ake, 1987:9), but this idea is somewhat at odds with the contemporary dynamic view of indigenous knowledge as that knowledge developed by indigenous people (continuously incorporating new ideas), as opposed to knowledge generated only by the international exogenous knowledge system. The contemporary view overcomes the misleading idea of a dichotomy between indigenous and Western knowledge. Few, if any, indigenous systems have developed entirely without absorption or adaptation of knowledge from external sources. Terms of indigenous can include borrowings or influences from outside (Chambers, 1983; Atteh, 1992), including externally derived equipment, materials, ideas and techniques if they are locally reinterpreted and transformed. Once people regard such incorporations as legitimate modifications or elements of their own culture then it can be argued that they have become 'indigenised'. The process is continuous and responsive to locally changing resource endowments. Of course, it is also exposed to power relations between local people and outside change agents (Scoones and Thompson, 1994).

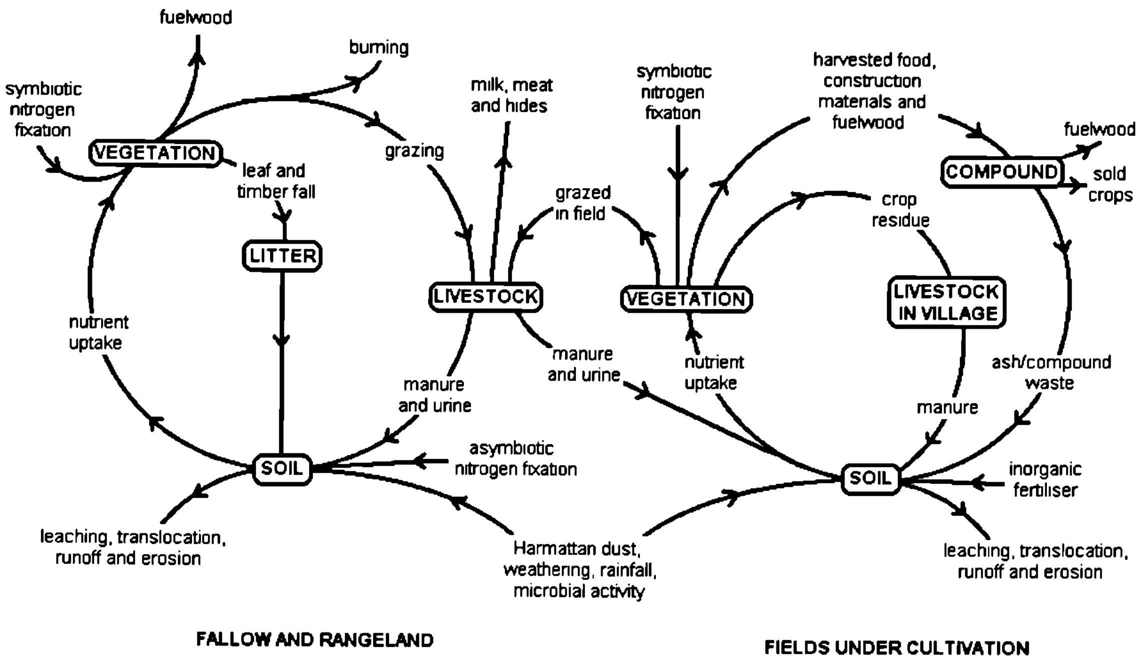
Although the approach is located within IK, the process of 'integrated nutrient management' allows a variety of methods to be combined (including the incorporation of scientific knowledge), and has been proposed as the only practical solution to maintaining or improving fertility for smallholders in the Sahel (Williams *et al.*, 1995; Powell *et al.* 1996; Smaling and Braun, 1996; Smith *et al.*, 1997; Meertens, 1999; Ramisch, 1999b; Breman and Sissoko, 2000; Lal, 2000). The methods can include targeted mineral fertilisers, livestock management, fallow and crop rotation, mulching and green manures, providing precision applications and micro-variability management to suit to each farmer and each location.

2.2.4 The ecology of soil fertility

Ecological theories have greatly influenced debates on land degradation and intensified farming in the West African Sahel. Since the 1970s, ecologists began to abandon earlier models based on systems theory, which describes ecosystems in terms of notions such as stability and carrying capacity (see review in Leach *et al.*, 1999). They now think in terms of non-linear relationships, uncertainty and disequilibria, and include aspects of human activity and influences at different scales (Altieri, 1987; Reijntjes *et al.*, 1992; Pretty, 1995; Conway, 1997; Shepherd, 1998). The 'new ecology' (Scoones, 1999) approaches the dynamic landscape as a mosaic (Kolassa and Pickett, 1991), with historical and social variability (Dunning and Stewart, 1991; Williams, 1994; Wong and Nortcliff, 1995). One popular method of understanding soil fertility is through nutrient balances, stocks, flows and cycling. Within the cycle, there are sources and sinks of nutrients, inter-linked by flows (figure 2.2). Land-use and farming management affect these processes.

Figure 2.2 shows that there are several sources of nutrients that may be applied to farmers' land-holdings. These sources include household waste, manure from grazing animals, green manuring, inorganic fertiliser, Harmattan dust, biological nitrogen fixation, and the passive fallowing of fields (see discussion in Hilhorst and Muchena, 2000). These are important sources for inputs of nitrogen, phosphorus and potassium. Losses can be accounted for by the crop harvest, removal of crop residues, fuelwood use, leaching, erosion, and through grazing.

Figure 2.2: Nutrient cycling in smallholder farming (*adapted from Harris, 1999*)



The productive capacity of a soil is not determined by soil nutrients alone. Organic matter plays a crucial role in maintaining the quality of a soil, as it improves the structure, facilitates aeration and determines the capacity of the soil to hold water and exchange nutrients. Any deterioration in organic matter will adversely affect these characteristics, and ultimately trigger further losses of nutrients through leaching and erosion. The level of organic matter influences the availability of nutrients to plants. The nutrients that are present in the soil solution, are immediately available for uptake. They are in equilibrium with ions absorbed by the complex of clay particles and well-decomposed soil organic matter. The capability of a particular soil to store nutrients is referred to as the cation exchange capacity (CEC) and when soils contain little clay, organic matter becomes a more important means for storing nutrients. Hence, in soils with low clay and organic matter content, applied nutrients are easily lost from the root zone.

Another source of nutrient exists in the pool of active soil organic matter; these become available through mineralisation within one or a few years. The size of the active pool, and its C:N and C:P ratios, determine how much nitrogen and phosphorus is available. A soil contains, in addition, stable organic matter pools that are not easily decomposed, only releasing nutrients over a period of a few decades. Soils also have mineral reserves of P and K from which nutrients are not available in the short term.

To maintain the cycle, the chemical nutrients removed by crops must be replenished; the physical condition of the soil must be maintained, which usually means that the humus level must be constant or increasing; there must be no increase in soil acidity or alkalinity, toxic elements or weeds, pests and diseases; and soil erosion must be controlled to be equal to or less than the rate of soil formation (Greenland, 1975).

One way to value natural resources is through the use of nutrient balances. Nutrient balance approaches look at the balance between the inputs and outputs into a given system. While some of the parameters in this analysis are easy to measure and estimate, others are more difficult. The balance for a given nutrient (e.g. N, P or K) can be calculated using the following equation:

Balance = [in1]+[in2]+[in3]+[in4]+[in5]+[in6] - [out1]+[out2]+[out3]+[out4]+[out5]+[out6]

Where: in1 = mineral fertilisers	and: out1 = harvested products
in2 = animal manure	out2 = crop residues
in3 = atmospheric deposition	out3 = leaching
in4 = biological nitrogen fixation	out4 = gaseous losses
in5 = sedimentation	out5 = soil erosion
in6 = uptake by deep-rooted plants	out6 = losses in deep pit latrines

These input-output models are simple (probably oversimplified) devices for understanding agricultural sustainability and have formed an increasingly important source of evidence on land degradation (e.g. Pieri, 1989; Stoorvogel and Smaling, 1990; Van der Pol, 1992; Smaling, 1993, Smaling *et al.*, 1996; Sanchez and Leakey, 1997). Studies using this approach have been carried out at different scales, from the continent of Africa, to national-level (using FAO statistics) to village-level and many have found alarming evidence of nutrient deficits. Table 2.1 gives a summary table of nutrient budget analyses at different scales, including village-level and field-level.

Table 2.1: Nutrient budgets at varying scales (source: Scoones and Toulmin 1999a)

Scale	Site	Rainfall (mm/yr)	Unit	Balance (kg/ha/year)		Source
				N	P	
Continental	Sub-Saharan Africa			-22	-2.5	Stoorvogel *et al.* (1993)
Country	Burkina Faso Gambia Guinea Mali Niger Senegal Chad			-30 -26 -46 -32 -14 -24 -24	-1.8 -1.6 -3.1 -1.4 -0.2 -0.9 -0.4	Van der Pol (1998)
Regional	South-western Kenya	1350-2059	Kisii District	-112	-3	Smaling *et al.* (1993)
	Southern Mali		region Maize Millet Fallow	-25 -29 -47 -5	0 0 -3 0.5	Van der Pol (1992)
	Southern Mali	700-1200	Production system 'average' 'intensive'	 -13 -21		Breman (1990)
Village	Burkina Faso (Sahelian zone)	450	Village field Sandy Loamy Clay	 0.1 -5.6 -9.9	 0.44 -0.34 -0.15	Krogh (1995b)
Farm	Western Highlands Kenya	1600-1800	Farm (incl. hedgerows)	-86	-3.8	Shepherd *et al.* (1995)
	Kisii, Kenya Kakamega, Kenya Embu, Kenya	1200-2100 1650-1800 640-2000	Farm	-102 -72 -55	-2 -4 9	De Jager *et al.* (1999)
	Southern Ethiopia Upland Lowland	 1250 800	Field Homefield Out-field Homefield Out-field	 -3 to -4.5 -54 to -95 -4 to -24 -20 to -40.5	 4 to 8 3 to 6.5 3 to 10.5 -1 to 6.5	Eyasu (1998)
	West Tanzania	800-950	Field Sandy (cotton/ cassava) Loamy/clay (rice)	 -17 -56	 0 -7	Budelman *et al.* (1995)
	North-east Nigeria	700	Farm	-28.2 to 2.5	-3.4 to 2.9	Harris (1996)
	North-east Nigeria	360	Farm	-8.98 to 1.18	-0.81 to 1.5	Harris (1997)
	Southern Mali*	800-900	Farm	34.4	5.4	Defoer *et al.* (1998)

* *Southern Mali – these strongly positive figures for average balance for N, P and also K (322.4kg/ha/yr) are the result of significant nutrient input from input from inorganic fertiliser, and nutrient transfers through grazing of animals on common pastures.*

Figures from studies of mixed farming systems are widely quoted (Fernandez-Rivera *et al.*, 1995; McIntire and Powell, 1995, both in Niger), although based on some questionable assumptions (Turner, 1995). The most recent analysis by van der Pol (1998) gives a negative balance for Niger of -14 kg/ha/yr N and -0.2 kg/ha/yr P. Van der Pol (1992) has been widely quoted for calculating that 40% of farming income is achieved through soil mining.

Many researchers have urged caution over the uncritical application of this approach, particularly the employment of aggregate studies to diagnose generalised problems and suggest blanket solutions (Krogh, 1997; Ramisch, 1998; 1999a; Scoones and Toulmin, 1999b). There are also difficulties and problems with a 'snapshot' approach when trying to understand longer-term dynamic processes and a danger in extrapolation to wider scales from limited specific data sets. The budget is dependent on erosion measurements that are usually plot-level and exclude temporal aspects of sedimentation and fallow rotation. However, these erosion-productivity relationships are difficult to establish (Erenstein, 1999). The loss of poor-quality topsoil may not be evidence for the loss of soil fertility where the soils are deep. Stocks and flows of nutrients are not necessarily correlated; the model inappropriately assumes a linear relationship between variables. Any assessment of long-term sustainability requires a separate investigation into stocks; it may be that large flows of nutrients are being used from a low stock or vice versa.

Furthermore, aspects of management and issues of natural capital substitution need to be considered. For example, nutrients lost at the field-level may not be lost at the village-level (Krogh, 1997). Management may be the key factor in explaining why on-farm surveys may lead to other conclusions than nutrient budget studies that have limited sensitivity to management (Scoones and Toulmin, 1999b).

An environmental theory that focuses on the physical ecosystem, does not describe why people change environments or the effect of soil depletion on different people. Recent studies by both Ramisch (1998) and Harris (2000) illustrate the great diversity in soil fertility results between villages, and between farmers (further discussion on these studies can be found in Chapter Nine, Fandou Béri in context). Harris (2000), working in Niger, found most sample sites did suffer fertility degradation and some farmers were able to manage land sustainably. Indeed, table 2.1 shows that soil fertility is apparently increasing in some areas.

2.3 Smallholder coping strategies

2.3.1 The development of agroecological thought

As Chapter One has already outlined, it is apparent from recent literature (Krogh, 1997; Scoones and Toulmin, 1999a) that a deep distrust of crisis narratives about the Sahel has developed (Roe, 1995). The distrust is implied in research ranging from that on soil erosion to those on social systems (Leach and Mearns, 1996; Eyasu, 1997; Harris, 1999; Mortimore, 1998; Howorth and O'Keefe, 1999; Mortimore and Adams, 2001). In particular, the notion of progressive decline in dryland agricultural production, which is prevalent in the agronomic community (Stoorvogel and Smaling, 1990; Bationo and Mokwunye, 1991; Powell *et al.*, 1999) is being challenged (Krogh, 1997; Howorth and O'Keefe, 1999; Scoones and Toulmin, 1999a). One of the bases of the distrust is the observation that smallholder systems, assumed to be so damaging in crisis narratives, persist. The reason for this survival lies in inherent complexity at different scales. The research debate has now moved away from crisis narratives to local narratives in which the problem is how best to represent Sahelian agriculture, in particular how to represent it in different systems of understanding (indigenous or scientific).

In 1983 Paul Richards identified 'an epistemological gulf fixed between scientific and indigenous knowledge systems' (in relation to West African farming), and there is still a concern about this gap. Agrawal commented in 1995 on the importance of examining the 'socio-culturally differentiated view of scientific and local people's knowledge' with respect to agricultural management. Leach and Fairhead (2000) have recently expressed concern at 'analytical dichotomies' in discourse perspectives.

Scientific approaches to soil fertility have failed to capture the complexity of agricultural practice. While technical appraisal has an important role in emphasising the role of rainfall and bioproductivity constraints, models of 'typical' farmers' responses do not allow for the reality of a varied socio-cultural environment (Guyer and Peters, 1987; Vierich and Stoop, 1990). For example, negative nutrient balances do not justify recommendations to farmers for the immediate use of mineral fertilisers. This is because farm households very often have short-term objectives that run counter to that advice, but which fit prevalent socio-economic circumstances (Sikana, 1993; McIntire and Powell, 1995). Scientific systems attempt to be generic in nature whereas indigenous knowledge systems are specific, interactive and allow heterogeneity (Tabor, 1990; Davis, 1996). The knowledge and understanding which rural subsistence farmers bring to risk management can be used to complement or direct scientific studies (Reij *et al.*, 1996) (see section 2.3.2 and 2.3.3). Most importantly, the linkages between soil fertility and society are complex and dynamic (Raynaut, 1997).

New research approaches have evolved to deal with this emerging complexity and are grounded in interdisciplinary studies (Vierich and Stoop, 1990). The emphasis has shifted from farming systems research to production research to research into sustainable production. While many hailed 'Farmer First' thinking as a step in the right direction, the 'Populist' strategies it promoted failed initially to integrate fully with local systems, or to translate the socio-cultural and political economic dimensions of knowledge creation, transmission and use into a usable framework (Thompson, 1993; Scoones and Thompson, 1993; Chambers, 1997; Brett, 2000).

The challenge is to listen and learn from farmers' own knowledge, and this is not easy. The emphasis is on understanding variations in soil fertility and the maintenance of soil resource quality through land management (Jarvis, 1996). Simpson (1999) pointed out that while many of the biological and economic attributes of traditional farming systems have been documented (Brokensha *et al.*, 1980; Richards, 1985; Warren *et al.*, 1995), and are becoming better understood through the growing body of agroecological literature (Bade *et al.*, 1997; Altieri, 1998; Cromwell, 1999), much less is known about the specific details of farmers' physical and biological knowledge and how this knowledge is used in making key management decisions. Raynaut (1997) contended that a full understanding of the complexities demanded closer engagement at the microscale than most studies had achieved. Adams and Mortimore

(1999) believed that the major deficiency in the dominant international research discourse was its lack of concern for the local.

Microscale studies are a real challenge. There is a need to examine particular decisions about the allocation of work between different fields and farm tasks, and what factors are important to these decisions in the farmers' perceptions. Within the farming household, understanding of environment and change inform complex economic and social decisions about when, where, and what to plant, how much effort to put into crop management, how much to spend on other non-farm activities, etc. The environment is central to daily, weekly and seasonal decisions about the way people cope and ensure economic survival. Furthermore, it is essential to understand the strategies of differentiated social actors (Scoones, 1997; Scoones and Wolmer, 2000).

The emerging focus on the smallholder is part of a general movement to consider populist, local solutions to the development of livelihoods, in what Chambers (1997) called 'Complex, Diverse and Risk-Prone' conditions. Many researchers are optimistic about the ability of smallholders to adapt (Richards, 1985; 1991; Mortimore, 1998; Abdoulaye and Lowenberg-DeBoer, 2000). However, despite this significant paradigm shift, land use allocation by smallholders is still poorly understood, and Chambers (1997) conceded that this kind of knowledge is not easy to acquire. Sociological and anthropological studies have aimed to discover why farmers behave as they do given the complexity and risks in crop production, and this includes examining some of the opportunities and constraints in farming (Gray, 1997; Simpson, 1999). Smallholders make use of many different microenvironments, and pursue very different patterns of cultural and economic behaviour, even when they live in close proximity to each other. Above all, their risk-avoidance strategies must be extremely dynamic, varied and flexible (Davies, 1996; Raynaut, 1997) (see section 2.3.3). This resilience and diversity does not fit with models that see farmers' strategies ranged along a homogenous path from shifting cultivation to mixed farming (Scoones and Wolmer, 2000).

Agroecological approaches to understanding local-level farming systems have had a large influence in the debate. Agroecology is a combination of agricultural science, ecology and elements of anthropology (Hecht, 1998). The methodology and practice of agroecological research stems from different philosophical roots than those of conventional agricultural science. As well as the agroecology itself, it addresses the social system within which farmers' work and helps to include farmers' knowledge. The underlying analytic framework, based on livelihood analysis, owes much to the theoretical and practical attempts to integrate the numerous factors that affect agriculture (for example, Chambers, 1983; Conway, 1985; Richards, 1985; Rain, 1999).

The expanding academic interest in 'traditional' or 'indigenous' ethnoecology has been seminal in the development of agroecological thought. Using this approach, farming in dryland environments, like the Sahel, cannot be viewed as a static process for simple analysis, but highly complex and dynamic, constrained by resource entitlement and always shaped by a wide range of risks and uncertainties (see section 2.3.3). This is because local management systems are cultural constructs and cannot be divorced from economy or culture and are thus difficult and time-consuming to research (Reenberg, 1996). Specific management decisions are embedded in this wholeness or integrity (Netting, 1993). It is at the micro-scale, that of the farming household, that the macro-issues of Global Climate Change or World Economy are 'articulated with humanitarian concerns and where the hands-on management of the Sahel is decided' (Mortimore, 1989).

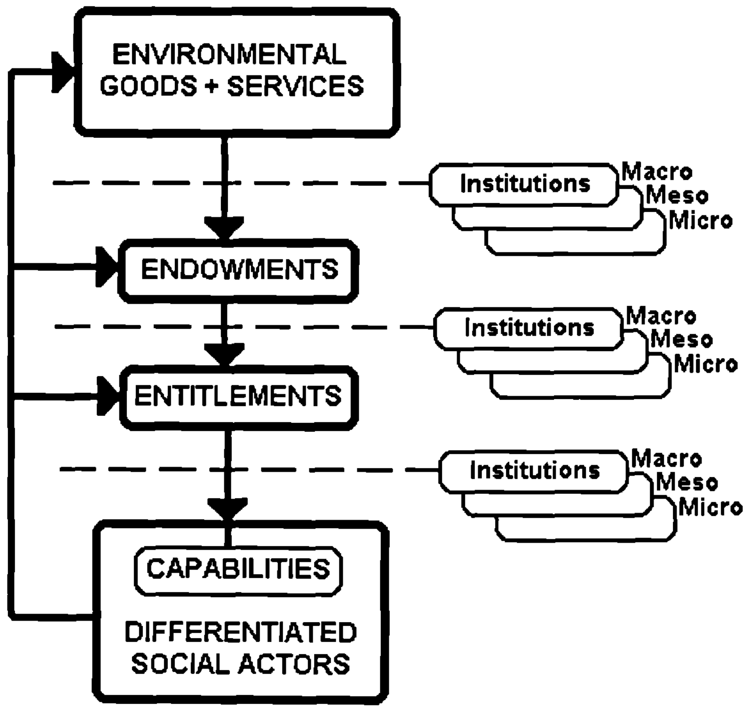
Although the physical causes and effects of local soil fertility change are obviously the terrain of the natural sciences, theories on the linkages in smallholder systems (between micro-scale and the wider framework of macro-influences) come from many disciplines. While environmental economics is less relevant in an operational sense, its attempts to explain decision making by farmers in the Sahel are valuable (Barbier and Bishop, 1995; de Graff, 1996; Bairoch, 1997; Barbier, 1997; 1998). Eaton (1996) provided a review of the assumptions made by economic theories. They tend to use 'typical' models of farmer response rather than examine social differentiation, yet different people at different stages of their lives adopt different livelihood strategies (Guyer and Peters, 1987). A differentiated view reveals much greater complexity. What these economic studies do reveal is that the social and the economic worlds that influence local-level decisions go outside the farm to include networks of social relations locally and with relatives and friends in towns. They also reveal links between national economic policies (in turn affected by international trends, and price levels, market functioning and levels of infrastructure and service support) (Ellis, 1998; Rain, 1999). They also show that external actors (whether government extension workers, development projects, religious leaders etc.) also have influence and that all these contexts are historically situated.

Although the question of why farmers invest in certain resources (or allocate productive resource differently) is largely economic, it is also subjective because land degradation and more broadly land use change are a social issue and subject to individual perceptions. There have been attempts to incorporate these social factors into environmental theories of smallholder analysis, the most prominent being 'political ecology'. Political ecology is an attempt to develop a theory of environmental change in its social, economic and political context (Blaikie and Brookfield, 1987; Bryant, 1992; Blaikie, 1995). It has been developed from research and experience in diverse settings in the rural developing world and is concerned with issues of class and power in society. As these issues interact with land management and land degradation Peet and Watts (1996) asserted that soil degradation results from a combination of forces. Many researchers have pointed to the complexity of processes operating at different scales and over different timeframes and argue that it is the constraints on human agency and creativity by political and economic processes that are important (Roberts, 1981; Macrae and Zwi, 1994; Batterbury, 1997; Batterbury and Bebbington, 1999). Investments of capital or labour can be used to improve the capability of the soil, a process that can be seen as a 'financial', 'human' or 'social' capital substitution for 'natural' capital. Analysis must include socio-political differences, as technology is never equally accessible to all people, and impacts on access to land, capital and assistance should be linked to the State and world economy (Bryceson, 1999; 2000; Brett, 2000). For example, Peet and Watts (1996) observed that affluence, as well as poverty, causes soil mining.

Blaikie and Brookfield (1987) argued for a qualitative approach, the need for case studies and a focus on local knowledge, where the land manager is central to the analyses. The approach has moved to focus on local scale research which can include issues of land rights, gender, class, ethnicity, political status, social relations, access and other forms of power (Scoones, 1998; Ellis, 1999). For example, ideas from the field of gender, environment and development (GED) are important in order to understand the differing impacts of livelihood vulnerability on women, men, various social orders and social classes (Rocheleau *et al.*, 1996; Agarwal, 1998). These approaches argue that the views of Western-dominated institutions are still characterised by a dualism between nature and culture and between nature and people, when in contrast the concept of landscape links ecological and institutional dynamics, with landscape history thus referring to the reflexive relationship between environmental and social history. Besides its articulation in political ecology (Bassett, 1988; Moore, 1993, Peet and Watts, 1996), this perspective has also been articulated in cultural geography (Cosgrove, 1984; Duncan and Ley, 1993) and in social anthropology (Bender, 1993; Guyer and Richards, 1996). The weakest area in these approaches has been their assessments of the means by which groups and individuals actually access resources, often seen as social capital (for example, environmental movements, civil society and environmental rights) (Hayward, 1994) and in understanding perceptions of access, such as entitlements (Wolmer, 1997).

While each household has a framework of 'capitals' or 'endowments' (resources such as labour, land, skills, cash, livestock, etc.) that they have rights to, different people have differing capabilities in legitimating command over this framework. Some social actors may not be able to mobilise some endowments (e.g. cash, labour) that are necessary in order to make effective use of others (e.g. land). The process of access is called an 'entitlement' (see Gasper, 1993). It was Sen (1981) who introduced the idea of 'entitlements' in relation to resource use. Entitlements connect one set of owned resources (such as labour) to another (such as staple foods) through certain rules of legitimacy (Swift, 1996). There are four types of entitlement. The first is the entitlement to own what is produced; the second is the entitlement to own what is traded; the third is the entitlement to own one's own labour; and the fourth is an entitlement to own through inheritance or gifts. These entitlements can be eroded (leading to vulnerability), protected (maintaining the status quo) or promoted (development). However, Leach *et al.* (1997) pointed out that the concepts are analytical constructs, and the distinction between them depends on the empirical context, on people's perceptions and on time. Ribot (1998) identified 'entitlement' as critical, indicating the need to map the chain events (including markets, labour, cash, social identity, power relations, and information control) that lead to a decision being made. Decisions on farm investment are filtered through social capital and this process is represented in figure 2.3. This process highlights the importance of understanding locally perceived concepts of access and entitlements (Leach *et al.*, 1999). The farming landscape is created through farmers' assimilation of this information. Somé and McSweeney (1996) termed this process a 'lifescape'. They defined 'lifescapes' as social, cultural and economic interactions that occur across a landscape. This implies a livelihood or production system that is dynamic and linked, although not tied, to place. A review of the World Bank's Poverty Assessment by Hanmer *et al.* (1999) highlighted the importance of these linkages. The present study sees the concepts of endowments and entitlements in visual geographies, and are key to understanding farm investment.

Figure 2.3: The environmental entitlements framework (source: Leach et al., 1997)



To understand these coping strategies or livelihoods, including aspects of different types of capital, methodological frameworks have focused on 'natural resource management systems' and multi-sectoral approaches (Reardon, 1995). These conceptual frameworks have become popular with policy makers, development agencies (Carney, 1998; Ashley and Carney, 1999) and academics (Scoones, 1998; Bebbington, 1999, Warren *et al.*, 2001) because they help to order the complexities in household decisions about natural resource management. Some frameworks see the household system within a constantly changing set of constraints (such as labour, rainfall, bioproductivity and capital) and responses (such as intensification of resource use, diversification into other livelihood strategies, and migration to other areas) (Tiffen *et al.*, 1994).

However, these models simplify livelihoods and fail to capture the multiple strategies employed within one household or the differences between households, and thus fail to show why particular decisions are made (as discussed in Rocheleau *et al.*, 1996; Scoones and Wolmer, 2000). Other frameworks have classified livelihood structures into capital assets (or the resources that farmers use to make decisions) but include a more complex framework of feedbacks and of structures and processes (larger scale influences that affect a livelihood's strength under stress e.g. climate, politics, economics, international (formal) and informal[2] institutional influences. Livelihood analysis using these 'sustainable livelihood' models can show livelihood outcomes for particular households. 'Sustainable livelihood' models claim to be responsive to people's own interpretations and priorities and provides the potential to explore whether there is a conflict between western perceptions of sustainability and farmers' decisions (Scoones, 1998). The approach is reviewed in Chapter Three (section 3.3).

2.3.2 Local knowledge and soil fertility management

In the past decade development professionals have focused their attention on mechanisms that can facilitate participatory decision-making, collaboration with clientele groups, and the sustainability of development project efforts in farming (National Research Council, 1991). While local knowledge (IK) is often seen as an achievement of the past, now becoming extinct under the impact of modern scientific knowledge, it is better described as a living resource; a form of local knowing that is

[2] This study defines informal institutions as regularised practices or patterns of behaviour that encompass arrangements such as: marriage and kinship networks, land tenure, markets, barter exchange, cooperatives, associations, herding contracts, manure exchange contracts and fodder exchange, migration networks, labour and draught-power sharing arrangements and cultural prohibitions on certain types of work.

constantly re-invented based on local farming conditions and culture (Röling, 1997; Röling and Brouwers, 1999).

IK is now viewed by many as the basis for indigenous approaches to decision-making, particularly through indigenous organisations where local problems can be identified and discussed, local knowledge can be explored, leading to 'indigenous' approaches to innovation and experimentation (Blaikie *et al.*, 1997; Warren and Pinkston, 1997; Prain *et al.*, 1999; Winklerprins, 1999). In the past few years there has been an enormous increase in the number of publications on these topics (e.g. Chambers, 1983; 1986; 1988; 1995; Amanor, 1991; Leakey and Slikkerveer, 1991; Warren, 1994; Sillitoe, 1998; Bationo *et al.*, 1998) as well as manuals and guides to methodology (Beets, 1990; IIRR, 1996; Center for Traditional Knowledge, 1997). Even some agricultural scientists have recognised the shortcomings in soil fertility research that poorly represents farmers' management (Bekunda *et al.*, 1997) and have incorporated IK into research trials in Niger. Despite research on cropping-livestock relationships, by ILRI and ICRISAT for example, inadequate participation and dissemination remains, while the studies listed above have focused on comparing and verifying local beliefs and practices within the framework of agricultural science.

Early cultural ecologists (or 'ecological anthropologists') documented farmers' practices and knowledge, albeit without much concern for experimentation and development (Steward, 1955; Leach, 1968; Netting, 1968). Later researchers (Thompson, 1973; Biggs and Clay, 1981; Rhoades, 1987) documented cases of indigenous agricultural problem-solving and adaptability and are reviewed in Rhoades and Bebbington (1995). Richards' (1985) work in West African farming systems was an important contribution. He criticised the 'top-down' approaches to help small-scale farmers, based on the concept of 'technology transfer', as being designed without reference to the problems, priorities and interests of those who were supposed to use them (Richards, 1986). Studies of 'indigenous knowledge systems', with local concepts and terms, were presented in a landmark collection (Brokensha *et al.*, 1980) and numerous reviews (Dvorak, 1993; McCorkle, 1994; Warren *et al.*, 1995). One USAID-funded project in Niger was based on an ethnographic analysis (McCorkle and McClure, 1995). These research contributions have illustrated that incorporating local knowledge into the research process is important because it helps to question the assumptions of orthodox agricultural science by comparing local and Western agroecological interpretations (Thrupp, 1989; Pretty, 1995). However, many ethnopedogical studies have focused on taxonomies, their aim to make local knowledge scientifically acceptable (Talawar, 1996; Winklerprins, 1999). It is more relevant to understand how farmers use their environmental knowledge for land management (i.e. to understand farmers' theories of change, processes of change and factors that they base their decisions on) and this study follows this approach.

The most prominent contribution is 'farmer participatory research', which builds on farmer knowledge, and has generated a huge amount of literature (Page and Richards, 1977; Biggs, 1980; Richards, 1985; 1986; Matlon, 1988; Tripp, 1989; Bunch, 1989; Warren, 1989; Chambers *et al.*, 1989; Ashby *et al.*, 1989; 1996; de Boef *et al.*, 1993; Brouwers, 1993; Dewalt, 1994; Berg, 1996; Joshi and Witcombe, 1996; McCorkle and Bazalar, 1996; Witcombe *et al.*, 1996; Witcombe, 1996; Sthapit *et al.*, 1996; Willcoks and Gichuki, 1996; Chambers, 1997; Innis, 1997; Scarborough *et al.,* 1997; Systemwide, 1997), reviews (Farrington and Martin, 1987; Amanor, 1989; Bentley, 1994), and catchy phrases such as 'farmer-back-to-farmer' (Rhoades and Booth, 1982), 'putting the first last' (Chambers, 1983), 'farmer first' (Chambers 1993), 'joining farmers' experiments' (Haverkort *et al.*, 1991), 'farming for the future' and 'low-external-input and sustainable agriculture' (Reijntjes *et al.*, 1992), and more recently, 'beyond farmer first' (Scoones and Thompson, 1994).

These more holistic approaches have shown that at the local level, the inherent temporal and spatial heterogeneity of natural resources is paralleled by an equally variable set of social resources and knowledge (labour availability, production objectives, skills and personal attributes of individual managers, etc.). Within the context of annual crop production, the convergence of these physical and social forces is best conceived as a dynamic performance (Richards, 1989). It is more accurately a set of linked performances, through which individuals respond to the evolving set of physical and social conditions within each year, and from one year to the next. The general nature of these cumulative and sequential performances is summarised by Moris (1991:27). African farmers respond to an unfolding scenario of changing opportunities and constraints (e.g. wet vs. dry years, early vs. late onset of the rains, pest outbreaks in a particular crop, unplanned labour shortages, and so forth), but also bring to their farming an accustomed 'script', modified as the season develops. This does not preclude strategic natural resource management plans and indeed the process in adaptive strategies operating over different scales and different timeframes has been well-documented (Reij *et al.*, 1996; Batterbury *et al.*, 1999). Mortimore and Adams (1999) defined 'flexibility' as short-term decisions about the use of a resource (e.g. deployment of labour, use of cultivar biodiversity, use of field location, use of grazing resources, other non-natural resource strategies) and 'adaptability' as longer-term decisions (for the next year and the future).

Farmers' capacity to enact successful agricultural performances and exploit an evolving range of economic opportunities is based almost entirely on the use of their own knowledge, communication and creative capacities. Research in Benin has shown the importance of local networks, where farmers learn from each other's experiences (Röling and Engel, 1989; Dangbégnon and Brouwers, 1991; Brouwers, 1993). Knowledge-exchange of practical information on new techniques (such as planting methods, manure application rates, planting times for different crop varieties, or the ability to suppress weeds) is a key process in the management of environmental microvariability as McCorkle (1994) found in her study of farmer innovation and diffusion in Niger.

Local environmental and ecological knowledge is an essential element in successful natural resource management. It enables individuals to exploit the various resources available to them and also make decisions to adopt, adapt, reject or develop (Simpson, 1999). Part of the agroecological approach has been greater attention to local environmental and ecological knowledge (Hecht and Posey, 1989; Tabor, 1990; Osunade, 1992; de Queiroz and Norton, 1992; Adegbidi *et al.*, 1999; Mango, 1999). There have been several studies of local knowledge in the Sahel (Taylor-Powell *et al.*, 1991a; Manu *et al.*, 1991; 1996; Dialla, 1993; Kanté and Defoer, 1994; Reenberg, 1994; 1996; Hopkins *et al.*, 1995; de Groot, 1995; Lamers and Feil, 1995; Krogh and Paarup-Laursen, 1997; Baidu-Forson, 1999). When making choices through the agricultural season, farmers also rely on weather patterns and constellations, the behaviour of certain plants, animals and bird species and plant associations (Osbahr; 1997; Simpson, 1999). Haverkort and Millar (1992:26) coined the term 'cosmovision' to describe the inter-relationship between spirituality, nature and people. It was reflected in farming behaviours that included no planting before certain religious festivals had taken place and carrying out some of the agricultural activities according to the stars or phases of the moon. Detailed knowledge of the requirements and tolerances of individual crops and varieties also aids farmer experimentation. Much of this type of environmental and ecological knowledge is culture- and even location-specific.

2.3.3 Risk in farming choices

Risk and uncertainty dominate people's lives in dryland areas. Whether it is variability at the field-level imposed by patterns of rainfall, the impacts of crop pests or the heterogeneity of soil types, or variability at a larger scale due to changes in market conditions, adjustments in economic policy, hazards of various sorts overshadow dryland farming livelihoods. There are many questions for local studies: how do farmers manage this variability, how do people make use of this diversity, what are the choices that farmers make? The way that livelihoods are composed, and how land-use decisions are made, are of central importance. Risk in the drylands has been a subject of analysis in agricultural economics as well as in livelihood analysis (Corbett, 1988; Chambers, 1989; 1997; Toulmin, 1992; Noordwojk *et al.*, 1994; Scoones, 1995; 1996; Reij *et al.*, 1996; Davies, 1996; Mortimore and Adams, 1999).

Before trying to research the diversity of agricultural activities, it is necessary to identify the sources of variability and diversity. Agriculture has an important spatial dimension: it is carried out in a variety of niches at different scales (Brouwer and Bouma, 1997; Lavigne Delville, 1997). Spatial variation occurs at the field level, with variations in soil types, topography, erosion and water flow dynamics, making a complex mosaic of different opportunities. Individual crops may use space in different ways, and with a variety of crop combinations and plant spacing, adding further dimensions of complexity. Weed infestations and pest attack can be a serious risk to crops, in particular from locust and grasshoppers and attacks occur in different spatial patterns. There is also landscape-level spatial management with choices between in-fields and out-fields and socially differentiated use associated with tenure. There are further constraints in the availability of labour, capital and nutrient inputs. Lastly, there are temporal instabilities in rainfall amount and distribution. Rainfall variability and its ecological and economic consequences dominate risk. The variability between and within successive seasons or years is especially relevant to farmers. Making use of this variability does not always mean success, as exogenous impacts can result in farmers turning to other sources of income during times of constraint or stress. This diversification in coping strategy means there is very much more to farm management than soil fertility. The rationale of diversification is fundamental and relates to the spreading of risk, which the key to the economic survival of the household. Risk management is achieved through maximising opportunities for the accumulation of wealth of either individuals or households, which often means tapping wealth flows in other regions or sectors through engagement in off-farm and (often) out-of-village economies.

Risk is of concern in farming systems research and development for several reasons. First, under-investment in management, including soil fertility, may be the result of people not being willing or able to take risks. Second, risks, shocks and stresses may undermine rural livelihoods in a way that increases their vulnerability, resulting in impoverishment and powerlessness. Case studies from Zimbabwe (Scoones, 1996) suggest that farmers have a wide range of strategies for managing variability in both time and space. However, this range of risk-management strategies is rarely taken into account of in the design and implementation of research and extension programmes. On the other hand, studies in agricultural anthropology have a long tradition of taking variation and diversity seriously (Richards, 1985). More recently, rapid and participatory rural appraisal techniques have been used to look at risk and decision-making though matrix-ranking exercises, personal construct analysis, etc. (Chambers, 1992; Chambers, 1997).

The realisation that the perception of risk is socially framed has important implications for policy and research. There is no 'right' way of deciding on resource allocation. Instead all responses in dryland management are based on values and preferences and demand a closer understanding of the choices that farmers make within their household livelihood structure.

2.4 Summary

While it has not been possible to present an exhaustive review on these many interdisciplinary and voluminous topics, this chapter has attempted to review the mainstream literature on farming and soil fertility management in the Sahel. The literature has highlighted the importance of soil fertility in concepts of sustainable agriculture and the contribution that micro-scale studies can make to our understanding of smallholders' choices for soil fertility investment and land use. It has also identified farming as only one part of rural livelihoods and has suggested that consideration must therefore be given to the wider framework and livelihood structure, in order to analyse household prioritisation in context. Most significantly, the review has drawn attention to the diversity of farming management and livelihood strategies in a risky and uncertain environment, and the importance of approaching this diversity from the farmers' perspectives.

3
Research methods and study design

Studying farmers' perspectives on the Sahelian environment is methodologically demanding because of the high variability in ecological, cultural and socio-economic factors. The choice of an appropriate methodology is critical. In addition to the diverse qualities of the research area, the usual influences of time and financial constraints demand flexible and adaptive data collection and analytical techniques. The approach adopted combined 'Grounded Theory' with participatory techniques and the study is set within the Sustainable Livelihoods framework. This chapter outlines the methodological orientation of the study, the reasons for using these approaches and summarises the study design and data collection.

3.1 The 'Grounded Theory' approach

The approach used in the collection of data is based on the seminal work of Glaser and Strauss (1967), namely, 'Grounded Theory'. The 'Grounded Theory' approach is an inductive, qualitative research approach developed for the study of complex social phenomena. The approach is based on the belief that proper categorisation and integration of data will allow the patterns of choices available to individuals to become visible, and permits the simultaneous proposition and testing of theoretical generalisations (Glaser and Strauss, 1967; Strauss and Corbin, 1990). To achieve this, the 'Grounded Theory' approach places a strong emphasis on both the use of specific research procedures and the subjective qualities of the individual researcher, who is viewed as the primary research instrument, responsible for carrying out iterative acts of data collection, analysis, categorisation, integration and hypothesis-testing. The validity and the reliability of conclusions reached under this approach depend not only upon the quality of the data collected, but also on the skill, theoretical sensitivity and creativity of the researcher in critically analysing, organising and integrating this information into accurate representations of social processes (Hall and Callery, 2001).

Through its explicit focus on the construction of theory, as the 'plausible relationships...among concepts' (Strauss and Corbin, 1994:278), the 'Grounded Theory' approach clearly sets itself apart from other exploratory research approaches. Conceptually, theory is said to evolve out of the continuous interplay between analysis and data collection, and is shaped by interaction between researcher and the actors he or she is studying. The continuous critical comparison of new data with the existing evidence and categories occurs simultaneously with the generation and testing of hypotheses that explain the relationships between the categories. The use of multiple slices of data, obtained from different sources and through different means, helps to develop the theoretical richness of the categories and their relationships with one another. This process is termed triangulation in social science and refers to the process of constructing 'multiple dimensions of data' (i.e. collecting data from different sources and therefore, different perspectives).

Nevertheless, the approach is not just a one-way process going from data collection to theory, because the developing theory guides data collection (Locke, 1996). The 'Grounded Theory' approach was chosen for this study because it fitted the research opportunity, and was capable of producing the type, quantity and quality of information needed for exploring the issues under investigation, with the existing time limitations and field conditions. Because of the exploratory nature of the main research issues, the approach needed to be capable of allowing the lines of inquiry to evolve with the acquisition of new information, rather than generating results that were more a product of the methodology. For these reasons fieldwork was divided into periods of field research with short periods of reflection to analyse data and raise further questions. Second, because farmers themselves hold the bulk of knowledge concerning their practices, the research approach needed to be capable of 'giving a voice' to these individuals, allowing them fully to explain their experience, perceptions and activities, rather than serving as a vehicle for validating the researcher's own hypotheses. Third, in undertaking this research there was a concern for producing results that could contribute to our general understanding of livelihood strategies in Fandou Béri and that could have practical applications in the future. The ability of 'Grounded Theory' to make such contributions is based on the belief that theory, 'carefully induced from diverse data', will have a high degree of explanatory power over the phenomena which it claims to study.

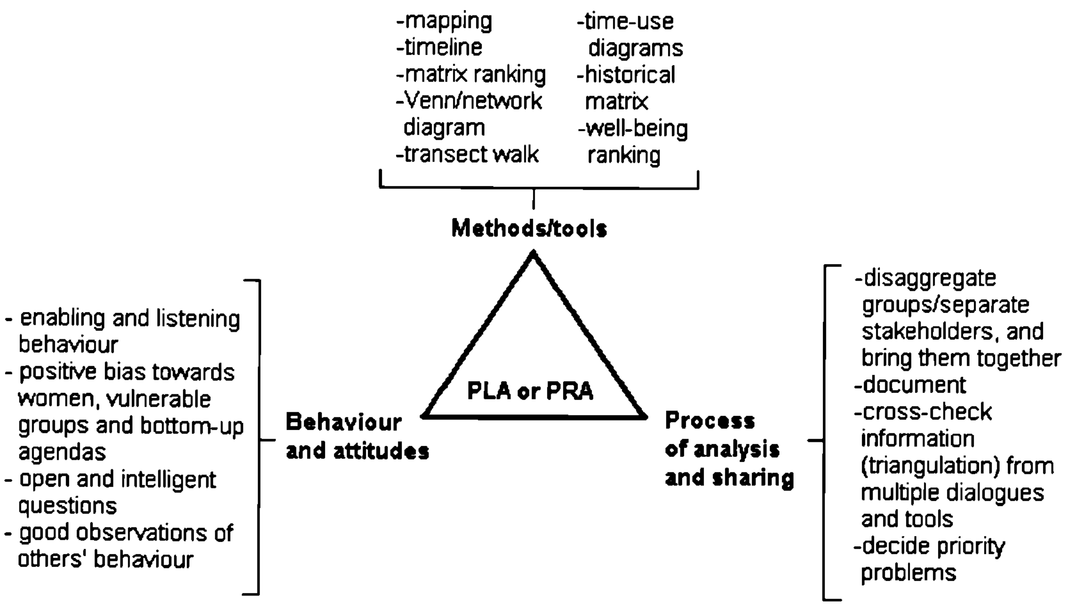
Finally, the 'Grounded Theory' approach acknowledges that data collection can be shaped by prior knowledge and investigations into the issues under study (Locke, 1996). While existing theory is useful during selection of the households for the study and broad topics about livelihoods for example, it does not drive data collection on land management decisions. Thus, the paradigm allows for the existence of multiple realities defined by different perceptions, both 'scientific' and 'indigenous'. The investigation was achieved by fusing 'Grounded Theory' methodologies with various participatory data-collection techniques (see section 3.2). In addition, conceptual categories developed by other authors in their analysis of empirical evidence were adapted to this study – a practice which, when done with the necessary caution, is consistent with the 'Grounded Theory' approach (Corbin and Strauss, 1990; Strauss and Corbin, 1990; 1994). This includes comparisons with quantitative and spatial analysis. The theory did not limit the variables and concepts that could be investigated but acted as a guide. The most appropriate of these frameworks is the 'Sustainable Livelihoods' framework (see section 3.3). Secondary sources of information (in this case, Project SERIDA data and other studies in other regions) can also be used to contextualise the results from the study village.

3.2 Participatory approaches

Participatory learning is an approach not a tool. Ideas of learning within development practice, sociology and geography produced PRA (participatory rural appraisal). PRA had developed out of RRA (rapid rural appraisal) and is now known as PLA (participatory learning and action) (Carruthers and Chambers, 1981; Chambers, 1983; 1994a; 1994b; 1994c; McCracken *et al.*, 1988; Guèye and Schoonmaker-Freudenberger, 1991; Guijt and van Veldhuizen, 1998; Guèye, 1999). The shift from PRA to PLA expresses the view that rural dwellers' activities are not just 'rural' and not just about 'appraisal' but also about learning and understanding social change (Okali *et al.*, 1994). In recent years a wealth of published material on PRA and related techniques has emerged (e.g. Kumar, 1993; Chambers, 1992; 1994a; 1997; Guèye, 1995; Neefjes, 1997)

The PLA approach centres on techniques using structured dialogue using a variety of methods, to share knowledge and analysis of everyday practice. Figure 3.1 depicts the three core aspects of PLA: tools, behaviour and process. PLA tools contribute structure to dialogues and yet help to retain a fair amount of real-life complexity regarding how the subject can be discussed. The tools avoid over-simplification and stimulate the discussion of inter-related problems, which can be taken as holistic analysis (Neefjes, 2000). The approach is believed to be able to open up the debate on local perceptions of problems and resource values, agricultural management and the complexities of social development and structures (Guijt and van Veldhuizen, 1998). The sampling methods facilitate the inclusion of different perspectives. Dialogue and interviewing methods help to create opportunities for as many to be involved as possible, in their own way, and on their own terms.

Figure 3.1: Basic aspects of participatory learning (after Neefjes, 2000)



A semi-structured interview or dialogue is often presented as a PRA tool, but Neefjes (1997) argues that this is a misconception because it is a process that happens in any encounter or interface. A dialogue is a two-way (or multiple-way) process of communication and not simply an extractive exercise, which is the common understanding of what constitutes an interview. 'Semi-structured' usually refers to the idea that certain questions and topics have been prepared by outside facilitators, possibly with aids such as a 'Sustainable Livelihoods' framework (Pretty *et al.*, 1995). A dialogue can also be semi-structured as a step-by-step interchange that is initiated by the facilitator (Chambers, 1997). Furthermore, some confusion still exists regarding the use of the terms RRA and PRA. RRA is concerned primarily with facilitating the learning of outsiders, while Participatory Rural Appraisal (PRA) is more oriented towards insider capacity-building as part of a larger process of change (Chambers, 1994b/c). There is often a false notion that RRA is not participative, and as it is not PRA, that it is also exploitative. However, RRA tools provide 'outsiders' with a clearer understanding of local situations, through dialogue, without elevating local expectations of aid. Participatory approaches can be used to identify important social actors. The main strategies of these actors that lead to social and environmental transformation can then be mapped along with other social groups, such as poorer households, to understand if they are relevant to the livelihoods and environments of these other groups. The social groups can also be separated into focus groups.

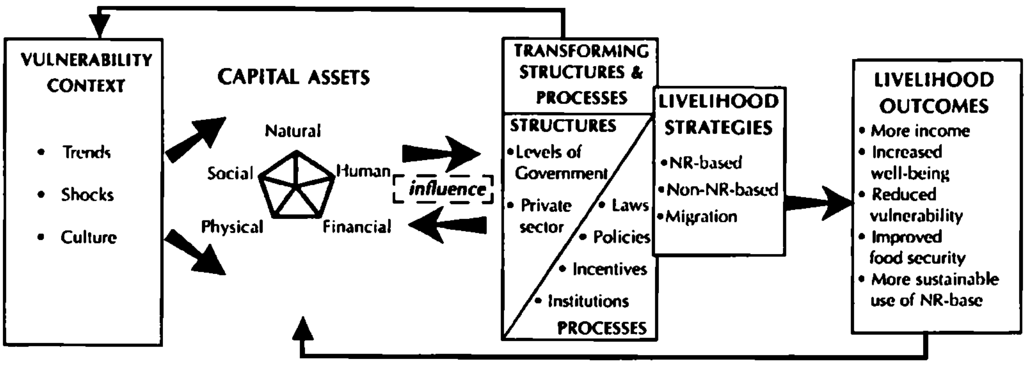
The use of indigenous knowledge has acknowledged problems, which include reliability and verification (Lett, 1997) and the rationalisation of action that can be tied to retrospective thought (after queries are made by observers). Therefore, participatory approaches to data-collection require careful use, interpretation and cross-referencing. There is a large literature on problems associated with PLA/PRA and other participatory approaches, such as sample structures, cross-checking, and monopolisation by dominant and articulate farmers (Richards, 1995; Chambers, 1997; Guijt and Shah, 1998). The researcher also faces the paradox of being an actor or facilitator and an outsider (Leach *et al.*, 1995). Cornwall (1998) also described the origins of 'gender naivety' in rural livelihood analysis as partly the result of the 'myth of community'; communities are diverse, and above all communities are social arenas in which power and politics are important as they are at any other level. She warned that participatory analysis must recognise cultural values, identities, and the differing positions of individuals and groups who move in different domains. Therefore, the present study focuses on case studies to build up detailed information and attempts to include information about women's activities and contributions, in order to understand more fully the apportionment of household investments to farming. Furthermore, Neefjes (2000) argued that while local environmental knowledge and perceptions are central to analyses, the linkages between macro-policy and local livelihoods can be misunderstood if RRA is used alone. For these reasons, a 'Sustainable Livelihoods' framework was used to provide a basis for the dialogue (see Chambers, 1997; Neefjes, 1997). A detailed critique of the methods used can be found in Chapter Eight (section 8.2).

3.3 The 'Sustainable Livelihoods' framework

The 'Sustainable Livelihoods' framework is used to place environmental issues within rural dwellers' lives and livelihoods, without ignoring the complexity of human reality (Hussein and Nelson, 1997; Neefjes, 2000). It can be used to explore the complexities in household livelihood strategies and decisions about natural resource management. The framework is essentially people-centred and aims to explain (in an abstract and simplified way) the relationships between people, their livelihoods and environments, macro-policies and informal and formal institutions.

The 'Sustainable Livelihoods' approach surfaced in the context of declining aid flows, the growing importance of the NGO sector, with its more restricted financial resources, and an emphasis on networking and increasing awareness of environmental degradation. The framework was developed during the 1990s, based on UNDP, CARE and OXFAM programmes, after attempts to improve environmental sustainability that were divorced from the social and economic context had met with limited success. It was felt that a more holistic appraisal was needed (Richards, 1990; Johnson, 1992; Chambers and Conway, 1992; Chambers, 1997; Carney, 1999). The approach was multi-sectoral and is commonly presented as a model for 'Sustainable Rural Livelihoods Analysis' (SRLA), as shown in figure 3.2 (Reardon, 1995; Scoones, 1998; Neefjes, 2000). The model is based on a version by Carney (1998), Chambers and Conway (1992), Scoones (1998), and the work of a committee on 'sustainable rural livelihoods' set up by DfID in 1998. The approach also focused the debate about the importance of defining 'sustainable livelihoods'. Definitions have been provided in Chapter Two (section 2.1). The approach has been popular with policy makers and donor agencies because it is claimed to help problem definition and to provide an analytical basis for understanding livelihoods (Carney, 1999). According to Carney (1999) it also stresses rural risk management being directed at reducing vulnerability, helps people to develop resilience to external shocks and to increase the overall sustainability of their livelihoods. Researchers are now beginning to use the 'Sustainable Livelihoods' framework (SLF) to understand coping strategies and rural livelihoods elsewhere in the Sahel (e.g. Brock, 1999).

Figure 3.2: The 'Sustainable Livelihoods' Framework



The framework, shown in figure 3.2, is a simplified representation of rural dwellers' livelihoods, but nevertheless does contain feedback arrows to represent flows between categories. For example, the 'livelihood outcomes' have an influence on how capitals (i.e. assets, capabilities) are built up, and how they are substituted for one another. SRLA is set around five different types of capitals, which individuals can draw upon to build their lives:

1. *Natural capital* is the environmental resource stock from which resources useful to a household's livelihood are derived, such as the soil, land, water, and other living resources to which members of that household have rights of access (wildlife/biodiversity). The quality of resources must be taken into consideration when assessing stocks. For example, land with few nutrients is of less value to livelihoods than high-quality fertile land. There is also the need for a distinction between environmental goods (i.e. stocks) and services (i.e. sources and sinks).
2. *Economic or financial capital* includes the resources available to people (whether as savings, supplies of credit, regular remittances, market takings) which provide

them with different livelihood options. It includes flows as well as stocks and it can contribute to consumption as well as production.

3. *Human capital* is the skill, knowledge, ability to provide labour (e.g. household demography), and health, which is important in the ability to pursue different livelihood strategies. Skills and knowledge provide a technical range of options (farming, livestock husbandry, and off-farm activities).
4. *Physical capital* is the basic infrastructure: transport, shelter, water, energy, communications, and the production equipment/tools and means that enable people to pursue their livelihoods. Holland (1999) termed physical capital as 'human-made' capital.
5. *Social capital* resources include networks, the place of the household in the community, membership of groups, relationships of trust, political influences, and access to and exchange in wider institutions in society upon which people draw in pursuit of livelihoods.

The supply of the capitals are variable between households (for example, with different status or wealth), in time, and in space. The capitals include tangible resources as well as human capabilities to create, use, maintain, and improve them. This is especially complex because not all human, natural or social capital actually contribute to material well-being or utility; it is possible to appreciate and value nature simply for its own sake and to demand education for spiritual development, which means that time, effort and money are spent to achieve something non-material.

Above all, the framework highlights rural dwellers' need to be flexible and adaptable. It allows analysis of complex livelihood strategies by identifying the multi-dimensionality and cumulative feedback within their livelihoods. The 'Sustainable Livelihood' approach provides a framework in which the analysis of the reality of cross-sectoral analysis is permitted; rural people do not live their lives in 'sectors'. Individual women and men, households and villages usually pursue multiple livelihood strategies and these strategies are based on a dynamic set of capitals.

The framework allows for the perception that there is no such thing as 'traditional' management of natural resources (i.e. the agricultural system is dynamic and this is mirrored in farmers' practices and goals). Each farmer absorbs different cultural and scientific opinions, develops specific knowledge and skills and adapts constantly. Farmers have to absorb different socio-economic and political influences, identified as transforming structures and processes. Structures are identified as organisations ranging from layers of government through to the private sector, and processes are identified as policies, laws, rules, and incentives. The feedback arrow from 'policies, processes, and structures' to 'vulnerability context' in figure 3.2 suggests that people cannot directly influence this context. For example, markets and legal restrictions have profound influences on the extent to which one capital can be converted into another. Convertibility is one way of viewing the role of diversification, as a method of coping with times of shock or stress (Carney, 1998). For example, natural capital may be turned into financial capital for the seller, and for the buyer physical capital if it used, or human capital if it is consumed as food. These flows of capitals make analysis more complex (see table 3.1). Furthermore, a household's choices depend on its degree of vulnerability and poverty, and on the capitals that it can access. The structures and processes determine the effective value of a capital for that household and who has access to it. The overall household strategy may be one of survival, or it may be one of sustaining and improving what the household already has and does.

Table 3.1: Substitution of capitals from and into the farming component

Type of livelihood capital	**Examples of substitution**
Human capital	Human capital increases with nutrition, health services, education and training, which are normally enabled by strong social capital. Human capital (labour and technical knowledge) forms the core inputs in the process of turning natural capital into physical capital (e.g. Fallow to cultivated land)
Social capital	High levels of trust and collaboration (social capital) enable individuals and households to get help from peers and to be obliged to return the favour at a later date, which shows a direct interaction with human capital (and respect). Good collaboration between people (high social capital) means that technologies and management processes develop that are essential in the substitution processes between physical and natural capital.
Natural capital	Soil, as an important form of natural capital, is used to transform capital into other forms of natural capital (crops and fodder). The land itself can be used to represent social capital, such as the loaning of a field or a large land holding. Livestock is in essence natural capital. Livestock may be kept solely for reasons of status or as a stock of natural capital, and only be substituted in times of crisis, or consumed. By being sold or used as collateral, it is being turned into financial capital. If it is given as a gift, it is investment in social capital. When its dung is used to fertilise fields, it helps production and can be used in transport (helping to increase social capital). Value is added to natural capital by using physical (e.g. chemical fertiliser), human (e.g. labour) and social (e.g. power) capital.

Physical capital	Physical capital ranges from chemical inputs into the production processes to infrastructure such as roads and water-supply systems. It also includes drainage systems, conservation structures or pasture maintained by people (i.e. requires human and social capital inputs) and inputs like dung and fertilisers (also physical capital).
Financial capital	Financial capital represents other stocks (i.e. natural or human or other capital that has been converted). It is an intermediary in all kinds of substitutions (transactions) between the other capitals, and in that sense represents wealth and utility. It usually takes the form of money but can also be accumulated in precious metals or livestock. Payments can also be 'in kind', such as barter-trade.

(after: Neefjes, 2000)

There are limitations to the capital assets approach when the framework is used for more than just ordering qualitative information. The use of the framework as an aid to policy and economic appropriation is particularly limiting because of the difficulties in defining or measuring some of the capital resources. In addition, there are a number of interpretations and perceptions of the categories (Bebbington, 1999; Neefjes, 2000). The high degree of abstractness means that local people rarely find it a useful tool for discussion. Even more problematic is the framework's use in economic analysis. For example, it is particularly difficult to cost social capital. A detailed critique can be found in Chapter Eight (section 8.1).

This study restricts use of the framework to guiding project planning, helping to order information, particularly in a qualitative form, and to prioritising what should be analysed in order to understand specific agricultural livelihood outcomes. It is used to reveal patterns about the status of capitals in particular groups and how these change over time. Participatory assessment of people's livelihood objectives should yield a picture not only of what people are aspiring to, but also of what they feel are the major constraining forces or factors (including how structures and processes affect their livelihood options). If people appear to be particularly lacking one capital, it is necessary to understand whether they feel that this is a factor that prevents them from moving forward, or whether it is a relatively unimportant. Likewise, if people are particularly well endowed in one capital (e.g. land, money or labour) in relation to others in their community, but are still unable to achieve sustainable livelihood outcomes, it is important to understand the 'critical capital' or the undermining structure and process.

3.4 Study Design

Drawing upon general approaches to participatory data collection (Chambers, 1994a), a four-step preparation process was used:

1. A period of pre-departure data collection, review, and preliminary problemisation of key research issues. The major areas of inquiry, identified using the 'Sustainable Livelihoods' framework, were broken down into individual research issues and questions. For each question, a minimum data set was established.
2. Each of the identified data needs were linked with at least two potential 'sources' thought to be capable of providing the needed information (interview and literature), as well as at least one additional source that could help to verify these primary responses.
3. The data needs and potential sources of information were paired with specific data-collection techniques deemed appropriate for the particular source and the type of information required, and which were manageable under the time constraints. Overall, the selection of different sources of information and data-collection methods was guided by the principle of 'triangulation'.
4. After linking the basic information needed, potential sources and testing different participatory methodologies, a flexible data-collection schedule was implemented. The multi-stage approach to data-collection allowed progressive immersion into the physical and social contexts of the study area.

The study focuses on case study research and the collection of qualitative and quantitative data. Although only a small sample is used, a case study strategy provides more accurate and deeper information than can be expected from larger samples. The fact that the case study strategy allows in-depth analysis and a mixture of research methods, makes it an important tool in exploring new concepts other than those stipulated by theory. For example, households may be miscategorised as poor or vulnerable if detailed information about their livelihood structure is misunderstood.

3.4.1 Rapid reconnaissance and village visits

Following presentations about the intent of the project and the different activities, and introductions to the village chief and groups of individuals with high social status, permission to carry out the research was granted. A programme of visits was prepared and a field assistant and translator employed. A rapport with the villagers had been established during my research in Fandou Béri in 1997 and the programme reflected my knowledge of the activities and commitments of the villagers. For example, meetings were not scheduled for Wednesday or Friday afternoons out of religious respect. It was also made clear to the villagers that I was not part of the SERIDA project or linked to any development project, and therefore not in a position to provide aid, but was returning to learn more about the rural way of life in Niger. The people that I spoke to knew that their opinions would be written into a report accessible to the scientific community and they told me that they believed it was important to value their skills and knowledge and hoped that the study would act as a link to scientists. The farmers were also assured that information would be treated in confidence, and therefore, names have been changed throughout the thesis.

Scheduled village visits were made with Djerma field assistant and translator (into French), Siddo Seyni. He came from the nearby town of Hamdallayé, and was therefore outside the social hierarchy of Fandou Béri. However, as an older farmer, he commanded respect amongst the villagers. His training and experience while working for a large French aid project and the Nigerien institute INRAN, allowed him quickly to familiarise himself with the project objectives and research questions. He was also aware that the translated answer should be that of the respondent and that judgement should not be publicly passed on any farmer's decisions.

The study chose to focus primarily on understanding the agricultural management, livelihoods and choices for Djerma families in the village because a Djerma translator was used and because the Djerma were the ethnic group who own the land. However, the study did include three Fulani families for comparison. An important reason for this decision was that during research with Fulani in 1997, the difficulties of working with cross-cultural translators were highlighted. These difficulties could be attributed to differences in ethnic status.

It was decided that the twenty heads-of-household from the SERIDA project[1] would be used for the study because of the detailed information already available for these households. These farmers had been selected by SERIDA using wealth-ranking exercises, consultation, and stratified sampling of fields. While the present study focuses on key informants (male farmers who are heads-of-household), understanding their activities and decisions within the household[2] and kinship networks was important because individuals do not act independently. There is often complementarity and mutual dependence between individuals in the households and between farming and other parts of the household livelihood structure (see table 6.1, Appendix 1).

During the initial village visits, time was spent observing and participating in everyday village activities, such as visiting the market, eating lunch with the informants, helping with the cattle credit scheme (see section 4.4.3), helping on the farm and walking between farmers' fields. Spending time on the farm was considered particularly important because it gave farmers an opportunity to discuss their perception of the condition of each field and their desired preparation action, and to observe and check the actual activities. It also allowed a familiarisation with each field, which was critical to the quality of the interviews. Detailed notes were made about each conversation and about events during each visit.

Semi-structured questionnaires were completed during initial conversations to identify key information about household farming systems and the dynamics within each household. They were also necessary to identify topics that had been extensively covered by previous projects (i.e. identify people's knowledge of 'degradation' or 'development' discourse) and to develop unusual areas of interest. Great care was taken not to lead the interviewee into 'degradation' or 'development' discourse by way of questions or comment. Examples of the semi-structure questionnaires are provided in the Appendix 2.

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[1] Social and Environmental Relationships in Dryland Agriculture (1996-1999), a collaborative project between University College London, Brunel University, the ICRISAT-Niger and the Institute of Hydrology (see Chapter Four).

[2] The household can be defined as a group of people, that recognises the authority of the same single person (head-of-household, usually a man), that lives together (wives, children and extended family, not always related) and contributes to the daily costs of living (Guyer, 1981; Vaugelade, 1991).

A series of complementary research techniques were field-tested and refined, including focus groups and individual semi-structured interviews, in-depth discussions, preference ranking, various visualisation and diagramming exercises, resource- and activity-mapping exercises, guided field visits and direct observation. Drawing on the strengths of the most successful methods, the primary research techniques for the main phase of the data collection were proposed. These are explained more fully in section 3.4.2.

In addition to guiding the methodological developments, insights gained from the reconnaissance visits led to other changes in the overall conceptualisation of the research. In particular, the information generated in these visits led to a number of changes in the main phase of field research. The most significant change was the decision to focus on the opportunities and constraints influencing the choices to farmers in land-use management and investment.

3.4.2 Main phase of field research and data-collection

The field data were collected over the main part of the growing season from April to August in 1998 (figures 3.3 and 3.4). It is acknowledged that this is not long enough to build up a complete picture of livelihood analysis and ideally it would have been better if in-depth analysis and participation could have been conducted over longer time (see Chapter Eight). Nevertheless, the data that were collected provided a rounded picture of household 'capitals' within which individuals were making decisions. Moreover, this information was supplemented with a longer-term picture from the SERIDA database. Given the financial constraints of the study, the period of data-collection was targeted at a time when the farmers in the households were making land allocation decisions and investing labour into the farming sector of their livelihood structure. By August, land allocation decisions have been made for the season. The study 'season' was also timed to coincide with the return of migrant workers to farm their land during the rainy season.

Figure 3.3: The fieldwork process

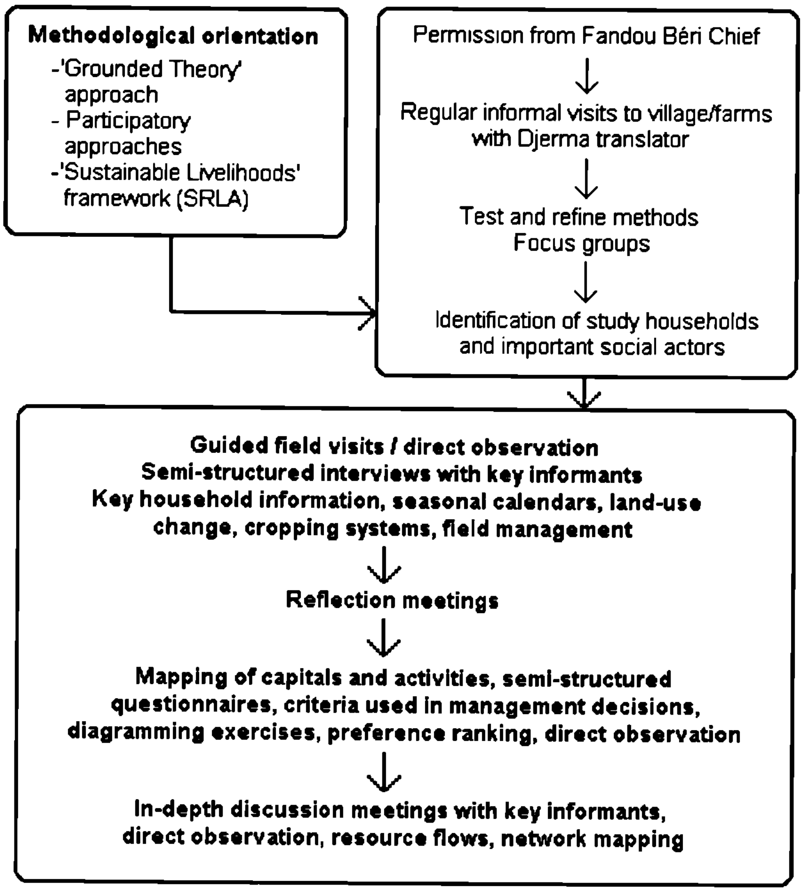


Figure 3.4: Schedule of data collection

Schedule	Location	Persons present	Activity*
April			
Meeting x2	Hamdallayé	SS/HO	Briefing/preparation
Meeting/visit	Fandou Béri village/chief's compound	SS/HO/chief and villagers	Social/permission
Over 5 visits	Fandou Béri village	SS/HO/villagers	Focus groups x10/ discussion meetings (non-sample households)/social
Over 5 visits	Fandou Béri village and on-farm	SS/HO/villagers	Individual meetings x10 (non-sample farmers) Test interviews/framing questions/ranking and mapping exercises
Over 10 visits	Fandou Béri village and on-farm	SS/HO/F1-20/ household members of F1-20	Social meetings with sample farmers and households x20 Guided visits to study fields x20
Meeting x2	Hamdallayé	SS/HO	Study day: review progress/schedule
May			
Completed over 8 visits	Fandou Béri on-farm	SS/HO/F1-20	Individual preliminary information sheets x20
Over 16 visits	Fandou Béri on-farm and village	SS/HO/F1-20/ chief/ study household members/villagers	Individual farm visits x20 cross-check/social
Visit x6	Fandou Béri on-farm	SS/HO/F1-20	Individual itinerary sheets x20

Over 5 visits	Fandou Béri on-farm	SS/HO/F1-10	Diagramming activities/ranking x10
Over each visit	Fandou Béri village	SS/F1-20	Collection of daily activities x20 (itinerary update)
Meetings x5	Hamdallayé	SS/HO	Study day: review progress/schedule
June			
Visit x6	Fandou Béri on-farm	SS/HO/F1-20	Individual itinerary sheets x20
Over each visit	Fandou Béri village	SS/F1-20	Collection of daily activities x20
Over 12 visits	Fandou Béri on-farm and village	SS/HO/F1-20/ villagers and chief	Individual farm visits Social/cross-check
Over 10 visits	Fandou Béri on-farm	SS/HO/F1-10	Management sheets x10
Over 3 visits	Fandou Béri on-farm	SS/HO/F11-15	Diagramming activities/ranking x5
Meetings x4	Hamdallayé	SS/HO	Study day: review progress/schedule
July			
Over each visit	Fandou Béri on-farm	SS/HO/F1-20	Itinerary sheets update/activity diagrams x20
Over 3 visits	Fandou Béri on-farm	SS/HO/F16-20	Diagramming activities/ranking x5
Over 10 visits	Fandou Béri on-farm	SS/HO/F11-20	Management sheets x10
Over each visit	Fandou Béri on-farm and village	SS/HO/F1-20/ villagers and chief	Social/cross-check/ farm visits
Visit x10	Fandou Béri on-farm	SS/HO/F1-10	Discussion meetings on interest topics x10
Meetings x5	Hamdallayé	SS/HO	Study day: review progress/schedule
August			
Over each visit	Fandou Béri on-farm and village	SS/HO/F1-20	Itinerary sheets update/activity diagrams x20
Visit x 11	Fandou Béri on-farm	SS/HO/F11-20	Discussion meetings on interest topics x10
Over each visit	Fandou Béri village and on-farm	SS/HO/F1-20/ villagers and chief	Social/cross-check/farm visits
Meetings x3	Hamdallayé	SS/HO	Study day: review progress/schedule

** Some activities, such as management sheets, farm visits and diagramming, were completed during the same visit.*

It was decided not to remunerate informants for information directly as this may have encouraged poor information, social tensions or a lack of interest from farmers. It would have been a direct contradiction to my stated position in the village. However, indirect payments were made in the form of culturally appropriate gifts, such as kola nuts and tea in meetings, or spices, soap and salt on return visits. Remuneration was given to farmers if they had to pay to replace their labour on the farm during meetings (at the local rate for labour – 250 to 500 f CFA) because time and labour were especially limited for households between May and July. Gifts were also given to households at births or festivals, as is customary. I received gifts of mangoes, chickens, eggs or lunch from the villagers in return for a favour (e.g. grocery shopping for some women, a taxi ride for an elderly man or his grandson to visit family in Niamey, help with a farm activity).

Short periods away from the field were built into the schedule to provide opportunities to review field-notes, reflect on observations, revise questions, discuss issues with other researchers in the region, raise new lines of inquiry and begin preliminary data analysis. Weekly reflection meetings also took place between Siddo and myself, and additionally included discussion of the political situation in the village and a reflection of our role within it.

Data-collection during scheduled visits to the village followed a similar pattern. The village chief was informed of the day's meetings and individual farmers were contacted and meetings arranged. Meetings took place in the fields to reduce interruptions to agricultural activities, to observe activities and to give the discussion context. Between structured activities, a range of informal discussions were held with individuals and focus groups (generally age-set groups) to cross-check information. Spontaneous meetings were often held during these visits. These helped to establish good working relationships, allowed participation in informal activities and generated a wealth of detailed information, such as unforeseen cultural insights, that would otherwise have been unavailable. The results of the semi-structured questionnaires, focus group discussions and secondary data review were used to identify the benefits of using simple 'visualisation' methods for data-collection (e.g. charts and diagramming techniques), which allowed the farmers to participate in the development of ideas (see Conway, 1989; Bradley, 1995) (an example of a semi-structured interview can be found in Appendix 2). These approaches meant that the project developed continuously in public, being the result of a two-way conversation which built farmer confidence and their interest in the results. The 'visualisation' methods served to reach understanding of four key themes that were central to the questions asked about household choices, agricultural investment and management and change through the season. These themes are discussed below.

First, historical diagrams, seasonal calendars and daily activity diagrams helped in the understanding of change over time, from long-term trends to the seasonal dimensions of poverty, production and consumption or to daily activities. These discussions aimed to reveal the dynamics of rural livelihoods in Fandou Béri. After these sessions, questionnaire files could be updated with additional information on individual field histories, personal biographies with regard to specific crops/technologies, and information exchange. In this way, temporal data could be collected on labour activities on the farm for specific tasks from April to August. Closed and open-ended questions helped specify field types, soils, intercropping patterns, rotations, varieties, soil fertility management, equipment, livestock, use of trees and plants, off-farm work, household demography, and drought coping. Project SERIDA had additional information on output, sales, asset ownership, transactions and income. These data could be used to understand the reasoning behind investments and transfers in capitals on the farm. Field activity monitoring sheets for all agricultural activities by field were updated during visits and gave a point of reference for starting discussions.

Second, differences in geographic space were explored using transect walks, farm sketches, flow diagrams, and social/resource maps and models. Mapping exercises proved a watershed in the information generating process because the technique focused farmers' interest and they claimed they were able to actively participate in the information process.

The third category focused on analysing the choices farmers made within their dynamic set of opportunities and constraints. Matrix ranking and scoring, and Venn style diagrams drew out the complexities, which were rarely accessible through formal surveys, and gave each individual household study more depth. They were also used to cross-check information in the SERIDA database. Matrices were particularly valuable for generating local criteria for selecting and evaluating particular management choices (for example, to fallow or to cultivate, and where to invest resources).

The fourth category used system and impact diagrams to look at flows of resources and information (or perceived cause and effect). These were more easily represented in conceptual 'maps' and the effects could be seen as output models. Conceptual or network 'mapping' was developed during the in-depth individual discussions. During these discussions the farmers chose to divide topics of conversion by processes of production, the seasonal calendar, climate and the environment, labour, capital and household, soil and livestock, biological variations, tenure and conflict, and cosmologies. This data-collection period was the most time-consuming. Repeated visits were made until all the staple crops had been planted, investments had been made in terms of labour and nutrients and the land-use for the farm in the 1998 season had been decided , after the weeding.

During the meetings, observations on a participant's behaviour served as prompts for further investigation of issues as well as cues for when to move to a new topic or to close discussion. Data collection needed to be carried out during a period of peak labour demand in order to understand how the constraints and opportunities changed through the season and to enable data to be cross-checked with direct observation.

The principles of verification, continual cross-checking of information, maintaining an optimal level of ignorance (not assuming knowledge, avoiding suggesting information, to reduce apprehension and encourage farmers to initiate conversation), reporting back understanding and probing into new and increasingly detailed areas, all played an important role in managing these sessions. Care was taken not to ask direct questions about knowledge within focus groups because farmers considered emphasising differences in skills to be impolite. Within the group setting farmers chose to discuss the flow of information in the discussion in terms of 'good advice', overcoming the problem of using the knowledge to publicly humiliate their friends.

3.4.3 Data analysis

Consistent with the 'Grounded Theory' approach, the collection and initial analysis of data took place in an iterative fashion throughout the main phase of the field research. In addition to the informal discussions and opportunities for direct observation, the periods between planned research activities were used to review and expand upon interview notes, record additional comments and observations and begin to look for areas of missing data or issues that would require further investigation. Regular revisiting of farmers provided an opportunity to compare developing conceptual criteria, household study information and local models with the 'Sustainable Livelihoods' framework. The process enabled a sequence of formulating, testing, revising and re-testing the hypotheses governing the relationships between the different conceptual categories. As a result, much of the theoretical interpretation of the research findings took place in periods of post-data collection analysis and the integration of secondary data (for example, the inclusion of historical change and time-series data on livestock, land-use, and crop yields).

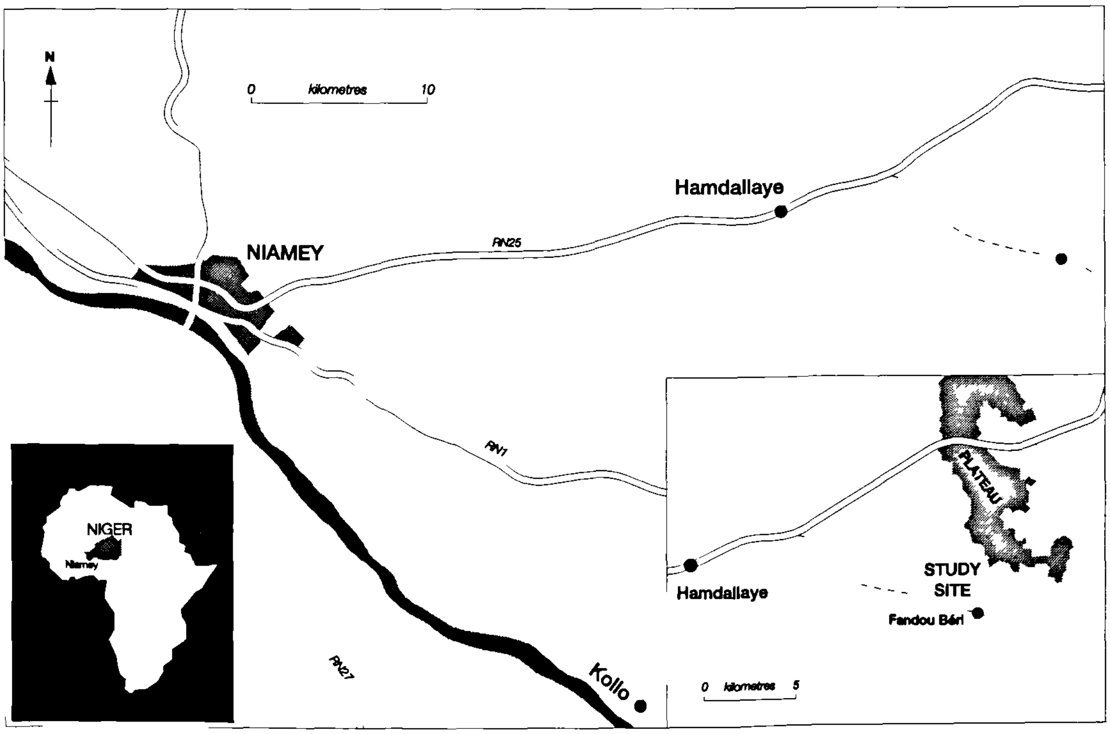
In addition, conceptual interpretations regarding agricultural 'performers' were taken from the literature and their use discussed with regard to the study data (Richards, 1989; Simpson, 1999). This is consistent with the 'Grounded Theory' approach as long as interpretations are critically reviewed. Explicit in the use of all such literature is the direct relationship of the information to the categories generated from the primary data collected during the field portion of this research. These additional sources of data were used to exemplify, contrast and add further detail to the field observations. Contextualisation with other studies in the region was especially important for this study because it focuses on livelihood strategies and soil fertility management in only one village.

PART II
Farming within a rural livelihood

4
Fandou Béri

The research was carried in the village of Fandou Béri (13° 33'N 2° 22'E), a small but regionally important settlement, near the town of Hamdallayé, south-western Niger (map 4.1, plate 4.1 and table 4.1). Fandou Béri is a hinterland village of the capital, approximately 50km north-east of Niamey (population of the capital is about 500,000). The village territory covers about $37km^2$ (map 4.2). The twenty sample farms can be seen as part of the mosaic of land use (map 4.2). Only the 58 fields cultivated in 1998 by the sample households are shown, their boundaries recorded by GPS (in 1996 by N. Taylor). Fandou Béri territory is marked as indicated by the farmers.

Map 4.1: Location of study village



Map 4.2: Field locations of the twenty sample farms in the Fandou Béri territory

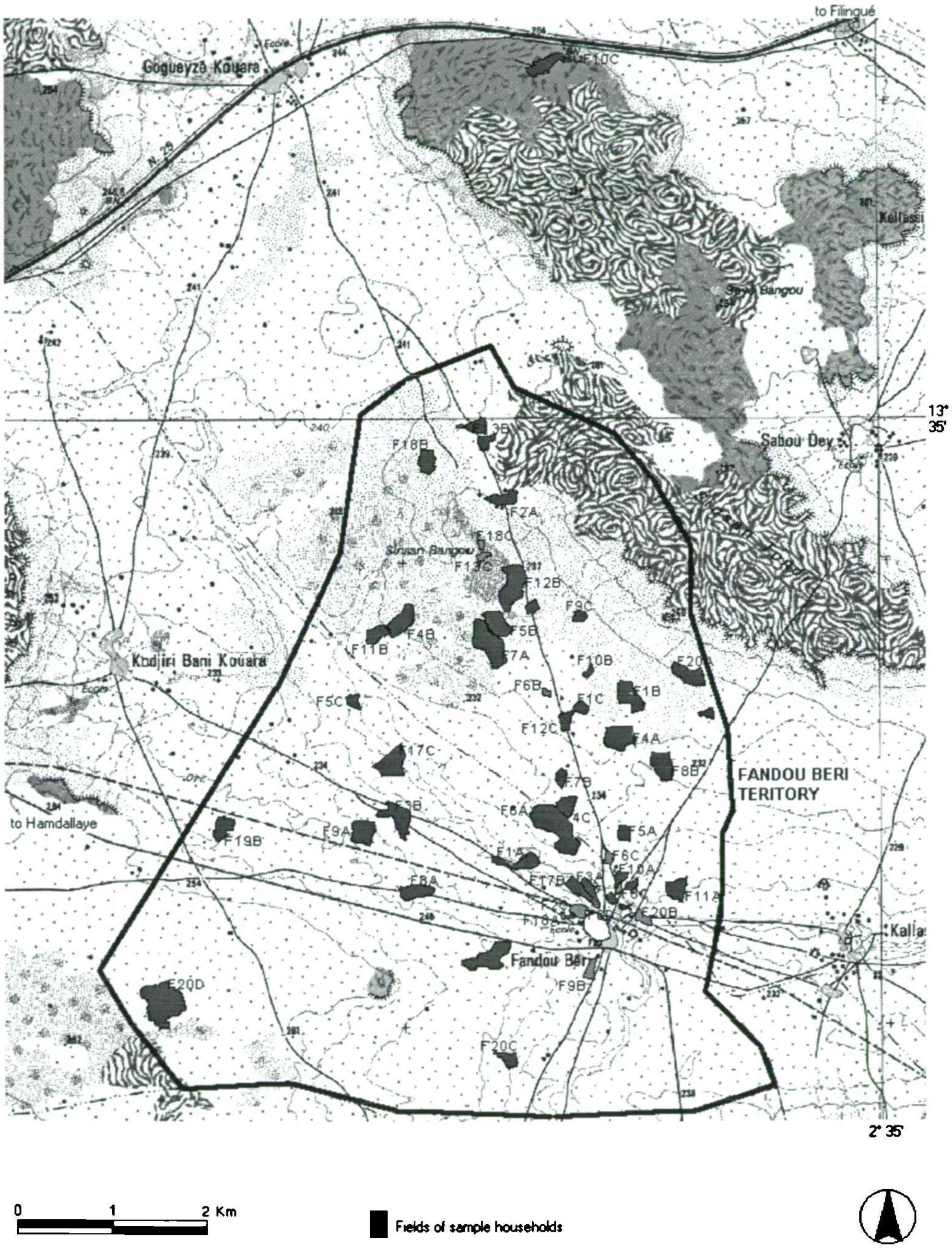


Plate 4.1: Fandou Béri

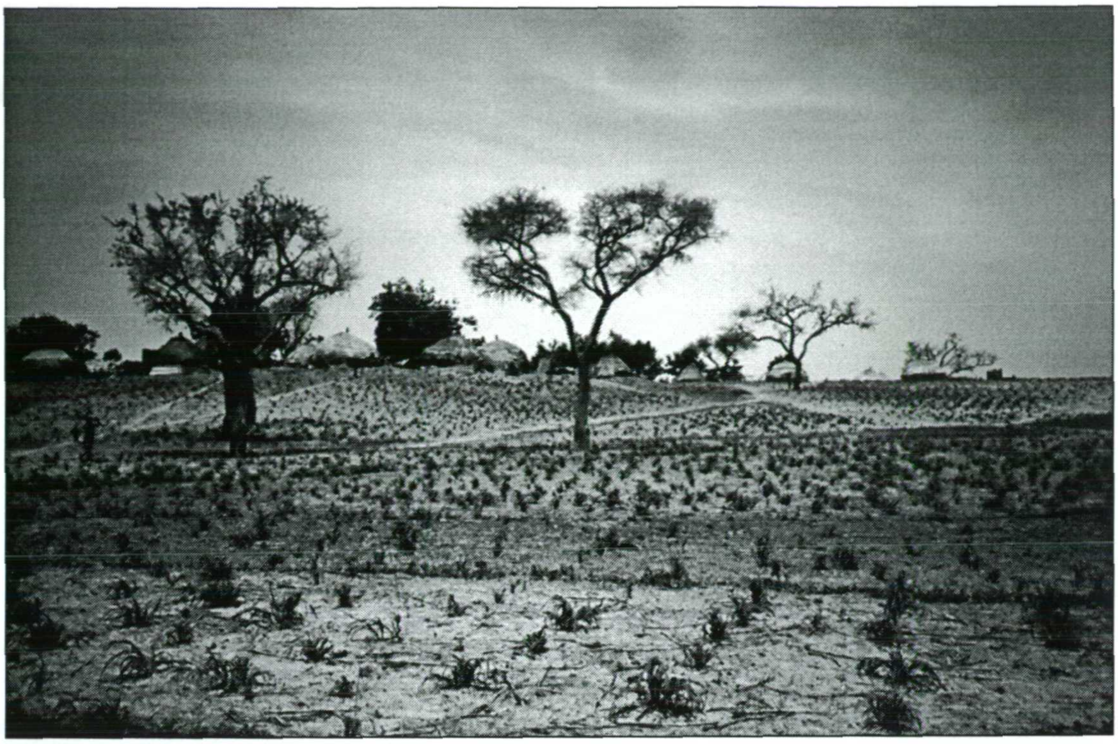


*Table 4.1: Characterisation of Fandou Béri**

Agroecological zone	Sahelian
Average annual rainfall	560 mm (1908-89), 547 mm (1991-95)
Length of rainy season	120 ± days
Soils	Sandy plain / fossil river bed /soft laterite
Village territory	Approx. 37 km^2
Estimated erosion rate in territory	- 40 t ha^{-1} yr^{-1} (Chappell, 1998)
Ethnic composition	Djerma (90%) Fulani (10%)
Approximate population and population density	750-800 people 20 persons / km^2
Principal crops	Pearl millet, cowpea, sorghum, hibiscus, groundnut, sesame
Cropping technology	Manual technology
Non-cropping activities	Livestock sales, seasonal migration, maraboutage, gathering, crafts, trading and petty commerce
Food security	4-6 months
Number of households in study	20
Average persons per household	10
Average livestock holdings:	
Djerma	19 animals
Fulani	89 animals
Size of farm	2-10 ha cultivated land
Average income level (f CFA)	253,802
% of household average income from non-natural resource sources	40

** For summary data on case study households see appendix 1.*

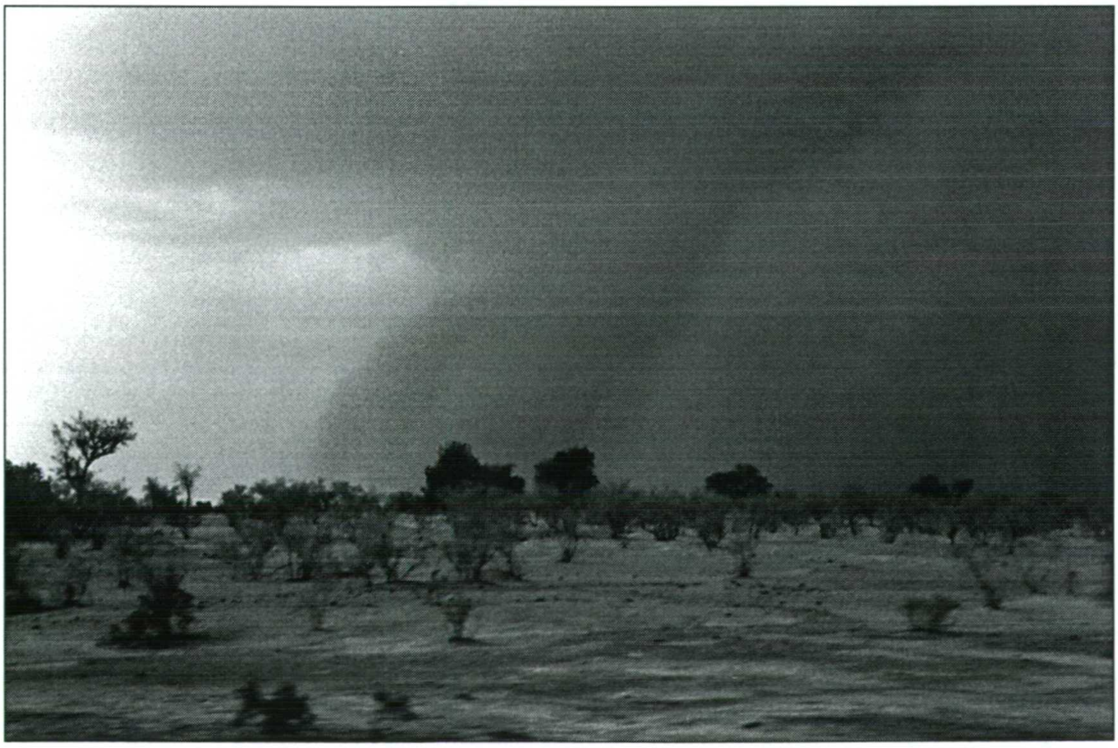
The village was chosen for several reasons:

1. Baseline environmental and socio-economic data had already been collected by scientific and development projects in the study village and surrounding area. Project SERIDA (Social and Environmental Relations in Dryland Agriculture) – a collaboration between University College London, the International Institute for Crop Research in Semi-Arid Tropics (ICRISAT-Niger), the Institute of Hydrology (UK) and Brunel University – collected data in Fandou Béri between 1996 - 1998. Information has been disseminated in a series of papers, reports and workshops (see Chappell, 1996; Chappell, 1998; Batterbury *et al.*, 1999; Warren *et al.*, 2001; Osbahr and Allan, forthcoming; Warren *et al.*, submitted) and closely linked theses (Chappell, 1995; Longbottom, 1996; Osbahr, 1997; Allan, 1997; Piper, 1998; Matthews, 1998). There are detailed environmental data from HAPEX-Sahel (The Hydrologic-Atmospheric Pilot Experiment, a programme sponsored by NASA) (Legger, 1993; Goutorbe *et al.*, 1997), the IGPB-SALT site and earlier studies (Manu *et al.*, 1991a/b; Taylor-Powell *et al.*, 1991). Satellite imagery and air photographs (HAPEX) and Japanese maps (1:50,000) cover the village. The nearby village of Banizoumbou, and an area to the west of Fandou Béri, has been intensively monitored over several years by ORSTOM, ICRISAT, INRAN, ILRI and Hohenheim University programmes on manuring and fodder crops, phosphate budgets, wind erosion, groundwater and rainfall variability, fallow and nutrient fluxes (e.g. Brouwer and Bouma, 1993; Williams *et al.*, 1995; Buerkert and Stern, 1995; Bationo *et al.*, 1995; Rajot *et al.*, 1996; Baidu-Forson and Renard, 1996; D'Herbes and Valentin, 1997; Bielders *et al.*, 1998; Brouwer and Powell, 1998; Hiernaux *et al.*, 1999).
2. It is considered representative of the land-use patterns, soils and livelihood strategies in the region.
3. Farmers are amenable to working with researchers, having had to work with previous agricultural development projects.
4. The site is logistically attractive because it is close to Niamey and accessible by paved road and well maintained gravel roads.

4.1 Climate

Rainfall in the Sahel is characterised by a well-defined monsoon season from April to September. Fandou Béri has a mean annual rainfall of c.560 mm (1908-89), or c.547 mm (1991-95) (Batterbury *et al.*, 1996). The characteristic large spatial and temporal variability in rainfall is a result of the randomness of prevailing convective storms. Inter-annual variation can be understood in terms of the advance and the retreat each year of the inter-tropical convergence (ITC) (Stern *et al.*, 1981; Taylor and Blyth, 2000). The advance of the ITC, which brings moist air northwards, determines the length of each rainy season, or the growing season for plants. In March the wind direction changes, the new winds carrying this moist south-westerly air. By April-May the relative humidity is more than 50%, with daytime temperatures reaching 40-43°C. The heat of the day builds convective clouds that create a storm front. Fronts move westwards as they form, creating winds of up to 50 kph and black-orange dust storms (plate 4.2). Sufficient convection brings the first rain storms. The duration of the rainy season in the Sahel is closely correlated with the date of the first rainfall event of the season (Sivakumar, 1987).

Plate 4.2: The first storm front of 1998 arrives in Fandou Béri (30th April)



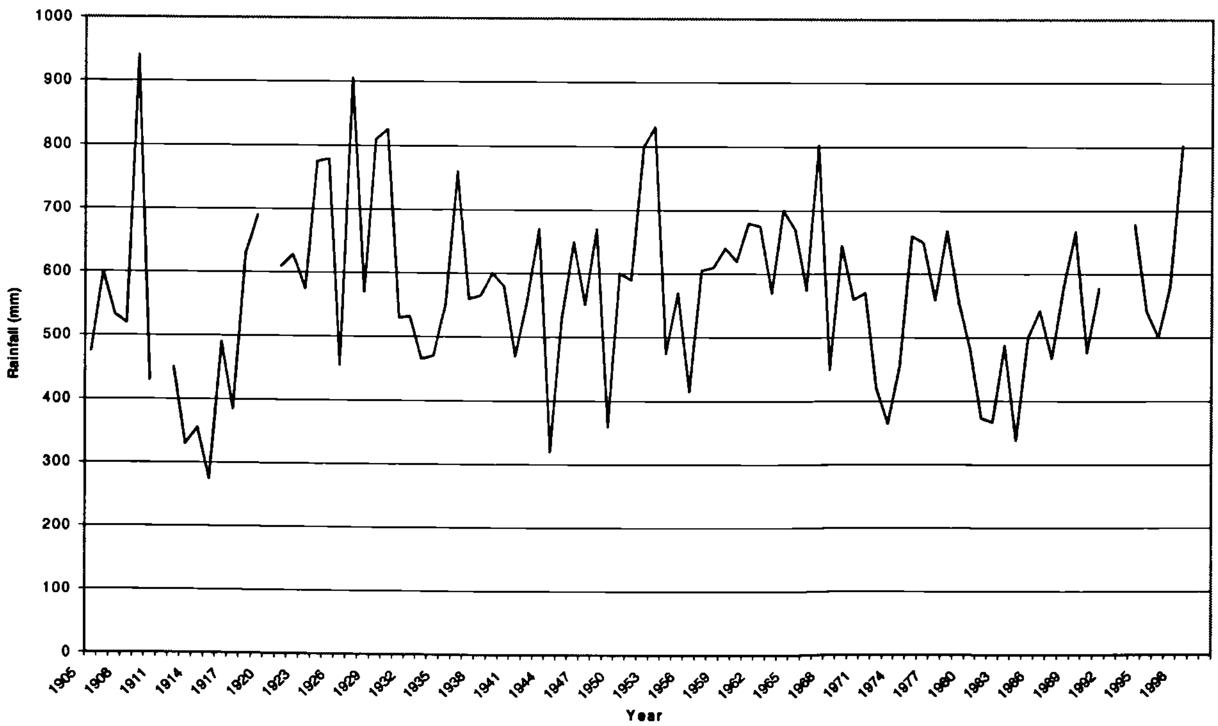
Agricultural production is limited to the short rainfall season. Scientific approaches to identifying the start of the rainy season use: the first month to have more than a stated proportion of the annual rainfall; the first month to differ significantly from the previous month; a positive water balance; or the reliability of rainfall in the first two-day or five-day period (Agnew, 1989). These can help to distinguish between meteorological drought (the impact of a shortfall from normal) and agricultural drought (the impacts of a dry year on a specific crop). Plant growth is possible when the balance between rainfall and potential evapotranspiration (PET) is positive. PET varies from 4 mm d^{-1} (rainy season) to 6 mm d^{-1} (dry season) and always exceeds rainfall except for a short period during the peak of the rainy season. Crop performance is dependent on the temporal distribution of rainfall within the growing season, soil moisture retention capacity, rates of runoff and the amount of rainfall. These factors promote variability in soil temperature, nutrient availability and microbial activity. Most notably, there are large seasonal variations in soil fertility because of the higher rates of mineralisation with the first rains (Wong and Nortcliff, 1995; Brouwers and Bouma, 1997).

4.1.1 Inter-annual regional rainfall variability

High inter-annual variability is the norm in this region, as the pattern of average rainfall over the last century shows this (figure 4.1). During the twentieth century, the community at Fandou Béri remembers drought years in 1912-14, in the early 1930s, early 1940s and early 1950s (Batterbury *et al.*, 1996). More recently, the Sahel suffered low rainfall years in 1965, 1972-3, and 1983-5, and again in the early 1990s and in 1997 (Gado, 1993; Bell *et al.*, 1999; Nicholson *et al.*, 2000). Within the 1990s, the 1997 rainy season was the driest and shortest.

Long-term rainfall data provide some evidence that between the 1970s and the late-1990s the growing season has shortened in Fandou Béri. The average rainfall available decreased from 119 ± 26 days per year (1945 to 1964) to only 108 ± 23.7 days (1965 to 1988) in the region (Seybou, 1993). The likelihood of droughty spells increased from the late-1960s, and many villagers report the onset of serious climatic-related stress from this time. Wang and Eltahir (2000) have recorded desiccation in their model between 1950 and 1980, while Hulme (2001) discusses concerns of climate change from the 1973 to 1998 records. However, when these drought events are placed in a longer timeframe, there is evidence that droughts have been common in the Sahel since at least 5500 BC (Holmes *et al.*, 1997; Hunt, 2000). Additionally, set within the longer timeframe records are years of above average rainfall (Buizer *et al.*, 1999). The wettest years of the last three decades in the Sahel as a whole were 1978, 1988, 1994 and 1998 (Nicholson *et al.*, 2000). There have been reports that the local effects in the Sahel of global climate change over the last century have increased in magnitude (Henderson-Sellars and Gornitz, 1984; Salinger *et al.*, 2000). While researchers have linked this climate variability with soil degradation (Feddema, 1999), vegetation cover and land surface albedo (Courel *et al.*, 1984; Brovkin *et al.*, 1998; Zeng *et al.*, 1999; Shinoda and Gamo, 2000; Ba *et al.*, 2001), atmospheric carbon dioxide (Arnell, 1999; Parry *et al.*, 1999; Wang and Eltahir, 2000; Lebel *et al.*, 2000), worldwide sea temperatures (el niño/la niña effect) (Folland *et al.*, 1986; Nicholson, 1988; Zheng *et al.*, 1999; Seager *et al.*, 2001; Vizy and Cook, 2001), and atmospheric dust (Middleton, 1985), although some theories remain controversial.

Figure 4.1: Long-term patterns in rainfall (mm) at Niamey 1905-1998

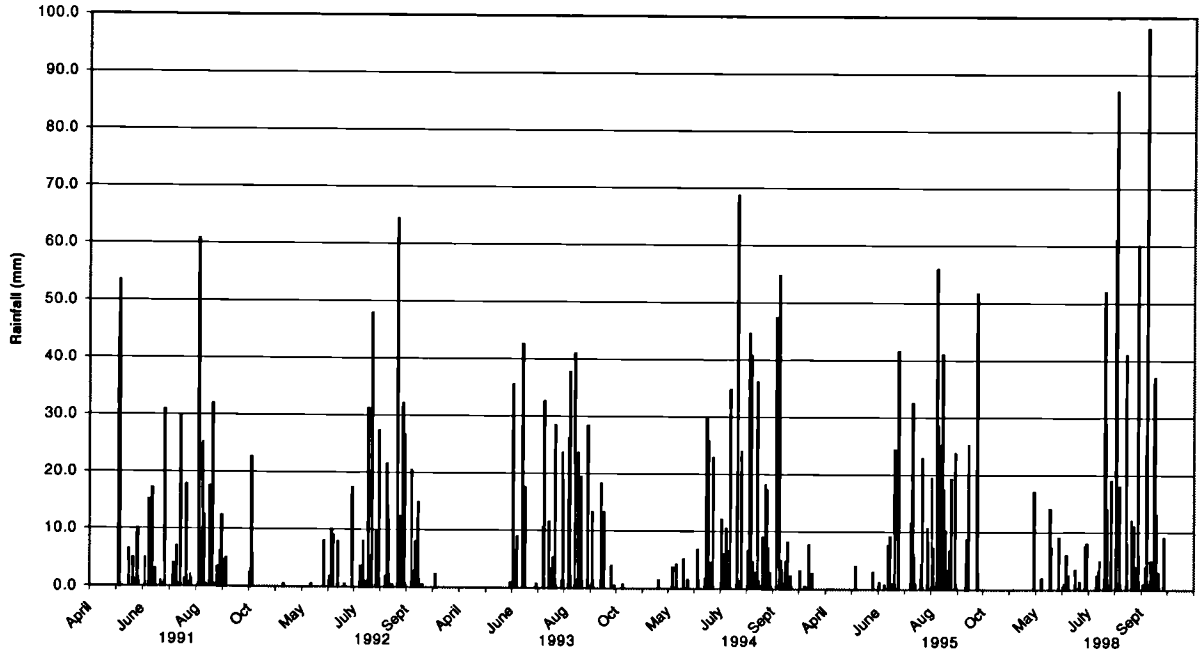


(Source: Institut de recherche pour le développement, ex ORSTOM)

4.1.2 Intra-annual rainfall variability

There are no long-term data available for Fandou Béri, but an automatic rain gauge was installed in the village in 1991, and the recent pattern can be seen from this limited data-set (figure 4.2) (note that 1996-97 data were unavailable).

Figure 4.2: 1991-1995, 1998 seasonal rainfall data for Fandou Béri



(source: Institut de recherche pour le développement, ex ORSTOM, own data)

Figure 4.2 and table 4.2 show that early season rainfall events (between April and June) are usually short and intense, and have a high variability. Rainfall through the 1998 season was better than the period 1991-95 (see table 4.2), as elsewhere in the region (Bell *et al.*, 1999), and between June and September rainfall was above average. While rainfall in the late-1990s, in the Sahel as a whole, has improved (FAO, 2001), the early-1990s and 1996-97 had combinations of high early-season winds, mid-season droughts, and intense, heavy rainstorms. During the four year period of the late 1970s, Hoogmoed (1981) found 36% of the storms in Niamey had a rainfall intensity >50 mm/hr, and 13% of the storms had a rainfall intensity of >100 mm/hr. Manu *et al.* (1994) reported that the average storm had a five-minute rainfall intensity of 47 mm/hr. These high-intensity storms can cause severe erosion (Bielders *et al.*, 1998). Surface pools and flooding can result. As the season progresses, the rain comes from patchy cloud and over more prolonged periods of the day and finally peter out by the end of the rainy season in September or October. Over the short-term, rainfall is patchy in distribution in space as well as in time. International research (e.g. HAPEX) has investigated the links between vegetation dynamics, evaporation, soil moisture and spatial rainfall variability (Taylor and Blyth, 2000). In periods of low rainfall, the spatial variability increases because the number of rain events becomes fewer.

*Table 4.2: Rainfall for Fandou Béri and nearby gauges**

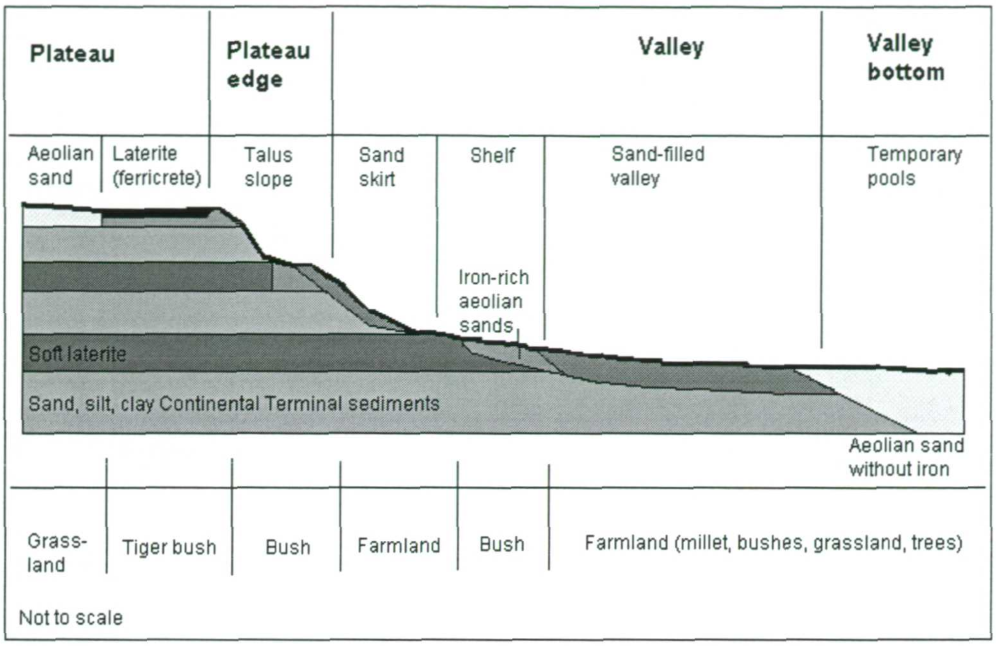
Year	Annual Rainfall (mm)	Date First Rainfall Event	Max Rainfall event (mm)	Days of rain	Average Event (mm)	Max period without rain (days)	Growing season length (days)
1989	402 (Hamdallayé)	-	-	-	-	-	-
1990	390 (Hamdallayé)	-	-	-	-	-	-
1991	544.7	Apr 3	60.8 (Aug 3)	52	10.4	26 (late season)	155
1992	479.7	Apr 10	64.3 (Aug 21)	43	11.2	15 (early season)	176
1993	491.3	May 30	42.6 (Jun 13)	34	14.5	13	132
1994	660	Apr 20	68.7 (Jul 21)	59	11.3	14 (early season)	179
1995	560.3	May 5	55.9 (Aug 7)	42	13.3	12	144
1998	773.5	Apr 30	98.0 (Sep 7)	49	15.8	9 (early season)	150

**Nearby gauges monitored by IRD (Institut de recherche pour le développement, ex ORSTOM)*
Note that 1996-97 data were unavailable

4.2 Soil toposequence and vegetation

Geomorphology and stratigraphy influence the distribution on the vegetation and soils in the region (Wilding and Daniels, 1990). Within the Fandou Béri territory, the dominant geomorphic feature is a broad flat ferricrete-capped plateau in the north of the village. The topography extends from the plateau through a short scarp and then through a slope or 'skirt' that is cut with gullies and rills, to a broad sandy valley that covers most of the territory (figure 4.3). A dry stream channel runs through the village.

Figure 4.3: Cross-section of a soil toposequence typical of the village territory (after Chappell, 1995)



4.2.1 Vegetation and soils on the plateau

The parent materials of the soils on the plateau are highly weathered ironstones. These soils are locally known as *tondobon* in Djerma. The soils are shallow gravely loams over cemented ironstone gravel (Manu *et al.*, 1991). These red stony soils are humus-poor, acidic (pH<5), sesquioxide-rich, low to moderately high in exchangeable aluminium, and have low CEC and low base status. Low permeability produces sheet runoff during storms that cuts rills and gullies in the scarp and leaves the surface with large coarse-fragmented gravel.

The vegetation on the plateau has a distinctive 'tiger bush' pattern that is typical of some semi-arid regions (Cornet *et al.*, 1992; Thiéry *et al.*, 1995). The vegetation bands (20 to 40m wide) are orientated parallel to the contour of the slope, and are separated by 40 to 60m sparsely vegetated 'corridors' (Valentin *et al.*, 1999). The development and maintenance of these vegetation bands is closely linked to rainfall and surface runoff (Thiéry *et al.*, 1995; Galle *et al.*, 1999; Valentin *et al.*, 1999; Guillaume *et al.*, 1999). The whole tiger bush pattern can be considered as an erosion-deposition sequence through space and time (Hiernaux and Gerard, 1999). The vegetation in the stripes is dominated by 2-5m high deciduous trees, the most common being *Combretum micranthum*, *Combretum nigricans* and *Acacia macrostachya*. The edges of the bands are vegetated with herbaceous species such as *Ctenium elegans* and *Pennisetum pedicellatum*. The soils under the vegetation bands are significantly deeper than in the 'corridors'; pH is 5 to 6 and they are humus-rich sandy loams over bands of soft laterite. The 'corridors' are barren, except for small pockets of herbaceous species growing on wind or wash deposits, with crusted soils. The vegetation on the plateau has been subjected to many years of heavy cutting, browsing and grazing. Manu *et al.* (1994) reported that many of the larger trees desirable for timber and fuel, such as *Acacia nilotica* or *Prosopis africana*, and many perennial grasses and palatable shrubs are not now common. The plateau is an important source of fuelwood, construction materials, rangeland, and herbs and medicines for the community.

The grassy 'skirt' slopes down to terraces where the ferricrete horizons come close to the surface, and loose soils are often less than one metre thick (Manu *et al.*, 1991). Vegetation is sparse and soils are impermeable with a highly compact surface. These soils are locally known in Djerma as *gangani*. Although difficult to cultivate, farmers do farm these terraces. The lower parts of the slopes have hummocky-terrain which may indicate spatial variation in soil loss (Chappell, 1995). Here the vegetated hummocks are 30 to 40cm high and 10 to 30m wide with sandy soils being separated by harder soils. Surface wash runs in localised rills and gullies from the plateau to the valley leading downslope to alluvial outwash fans.

4.2.2 Vegetation and soils in the valley

In the valley the sandy soils (Psaments) are developed on stabilised dunes, formed in the late Pleistocene (Bergoeing and Dorthe-Monaction, 1997). These well-developed, deep soils, locally known in Djerma as *tassi*, are the site of most of the cultivated fields of the village. Constant reworking of the soils by water and wind preferentially redistributes the most readily movable fractions (the small clay particles) into soils locally known in Djerma as *tassi-gandi*. The sandy soils of the broad valleys suffer wind and water erosion (Buerkert *et al.*, 1996; Bleich and Hammer, 1996). Despite the addition of wind-derived dust to these soils, clay contents are low (Bielders *et al.*, 1998). The soil profile for these *tassi* soils is typically coarse near the surface becoming finer with depth because of clay illuviation (Legger, 1993). Characteristically highly compacted reddish brown (loamy) sand overlies red sandy loam in a clay-enriched B horizon. The surface soil is spatially variable but is generally acidic, extremely low in organic matter content, has poor structure and a low moisture-holding capacity. In these pH conditions, phosphorus rapidly becomes unavailable and there are free aluminium ions, which can become toxic to plants. Available phosphorus (Bray 1P) is low and levels are often less than 8 mg P kg^{-1} (Manu *et al.*, 1996; Allan, 1997), this being the critical P level required to obtain 90% of the maximum millet yields (Manu *et al.*, 1991). Soil fertility analysis from fallow land is available in Allan (1997). West *et al.* (1984) gave figures for plant available water as 0.05 to $0.2cm^2$. CEC values are generally less than 3meq/100g. Base renewal by biocycling is insignificant because of the intense leaching associated with rapid infiltration through the sandy soils and because of the removal of crop residues from fields. Hartmann and Gandah (1982) found that in sandy soils with less than 15% clay and silt contents had an infiltration capacity reaching 30cm $hour^{-1}$. Gandah (1999) concluded that leaching was responsible for the loss of nutrients from high manure inputs (over 3 tons ha^{-1}). Crust types identified in the valley soils include vesicular, algal (cryptogamic) crusts (locally known in Djerma as *korobanda*) and crusts related to the exhumed clay-rich Bt horizon (Piper 1998; Graef and Stahr, 2000). Exposed *gangani* hardpans occur in patches ranging in size from $1m^2$ to $10m^2$. In a dry state these are particularly hard to cultivate and are prone to rapid runoff.

Soils of the dry channel system are more variable in texture and drainage than those in the rest of the valley. Although mostly sandy, there are units with high clay percentages (locally known in Djerma as *botogo*); the clayey units have water tables close the surface during the rainy season (Spath and Francis, 1994). These soils are neutral to alkaline and Na_2Co_3, present in the groundwater, maybe translocated to the surface in capillary rise and lost to wash erosion (Manu *et al.*, 1996).

Various plant communities reflect the spatially variable characteristics of the soils (Osbahr, 1997). The vegetation in the valley grows in a more random arrangement than on the plateau and can be termed 'open parkland'. Many of the trees of the original savanna, such as *Combretum micranthum, C.nigricans, C.glutinosum, Acacia* *senegal* and *Faidherbia albida*, were cut before enforcement of national laws designed to protect trees. There has been little seedling establishment of trees and shrubs in the last few years because of drought, increased cultivation, and heavy dry season grazing. The vegetation on the deep sandy soils is now confined to fallow areas or gardens (e.g. *Azadirachta indica* neem or *Mangifera indica* mango). The vegetation of fallow areas is dominated by species that quickly colonise disturbed sites and discourage grazing through various defence mechanisms (for example, bad taste, sharp seeds, or high silica content). The dominant shrub (*Guiera senegalensis*) and grasses (*Aristida longiflora, Aristida pallida, Eragrostis tremula,* and *Andropogon gayanus*) have these traits. Species distribution also follows topography, with the most water-demanding species found close to gullies.

The literature reports a degraded flora for the area, with a high genus-to-species ratio and the disappearance of several species (Manu *et al.*, 1991; 1994; Batterbury *et al.*, 1996; Wezel and Haigis, 2000). Commonly found annual species associations which are representative of poor soil are *Mitracarpus scaber*, *Aristida pallida/longiflora*, *Ipomoea involucrata* and *Eragrostis tremula* (based on comparisons between farmer knowledge, and plant enzyme and soil analysis (Osbahr, 1997). In fallow, soil spatial microvariability is accentuated by the vegetation, some soils having higher fertility because of the additional nutrient input from litter fall and nutrient cycling. *Faidherbia albida* is renowned for the '*albida* effect' where higher crop yields are obtained under the trees than away from the tree canopy (Geiger *et al.*, 1994; Payne *et al.*, 1998). These soils exhibit better biological activity, which is characterised by numerous biochannels, biopores, biocasets and fine roots, aiding decomposition and structure. Termite activity and human activity also contribute to soil microvariability (Geiger *et al.*, 1993; Manu *et al.*, 1996; Buerkert *et al.*, 1998).

4.3 Social change

The establishment of Fandou Béri can be traced to Djerma expansion out of the fertile Dallol Bosso region to the west in the 17th Century (Batterbury *et al.*, 1999). The Djerma are descendants of the Songhaï. The village expanded and increased its influence under French colonial rule from the end of nineteenth century, when Djerma warfare ended. In the French period, a dirt road was built past the village, which was then used as a staging post for troops and conscripts. Colonial taxation demands (paid in francs), forced labour and crop-pricing policies were responsible for significant movements of people who were seeking cash or evading authorities, and this increased the importance of the cash-economy (Olivier de Sardan, 1984; Charlick, 1991). Famines, recorded in 1928-31 and 1953, had been blamed on colonial negligence; in the 1930s only four families were left in the village (Salifou, 1975; Grolle, 1997).

After Nigerien independence in 1960, the population in Fandou Béri increased to over 300 people, although rural taxation remained high (Stoller, 1995). Raulin (1961) plotted the expanding territory at this time. Local commerce and the village agricultural system grew as the road system improved, increasing villagers' access to larger markets, including Niamey, which was under two-hours by bush-taxi. Fulani settled in the village, attracted by the prospect of mixed farming, and were given land by traditional lineage families and an influential marabout. While drought struck the village again in 1973 and 1983-85, they did not reduced the population so significantly. However, the cumulative effect of drought, fuel crises (1973 and 1979) (reducing exports, creating local food shortages and damaging the haulage industry) and the low market prices for cash crops reduced opportunities in agriculture. Many households in the region increasingly turned to the informal sector to replace the lost income (King and McGrath, 1999).

Six family lineages of the founding villagers can still be found in Fandou Béri, which now has a population of approximately 750 people, two wells, a school, a mosque and a market. As Sunni Muslims, the community considers farming a male role. Current calculations estimate approximately 20 people per square kilometre in the territory. Although there are fields outside of the territory, the area controlled by Fandou Béri is smaller than that of Darey (65km) and Tondikiboro to the east (80km), which are Djerma villages of similar age (Loireau, 1995).

Djerma are the main inhabitants of the village. Although Djerma are traditionally cultivators, several Fulani families have settled or predominately cultivate in the territory in the last 20 to 40 years. These Fulani cultivate land borrowed from Djerma, while their other household members are still occupied with herding. The village system of governance has a *chef du village*, a post once occupied by Djerma warriors although now by an 'elected' official (who is responsible for tax collection). The *chef du canton* at Hamdallayé is locally important and Fulani have their own representative. Political parties were once active, but decreased their campaigning social activities after the military coup of 1996. Social tensions over the chieftaincy and inter-village relations have influenced the pattern of farming (see section 4.5). Social change has led to more nucleation of households, and greater individualisation. This is partly the result of the politics of colonialism that encouraged migration, as well as Islamic inheritance laws and economic independence of the male youth (Olivier de Sardan, 1984). The household composition of the sample case studies is presented in table 4.3.

Table 4.3: Study household composition

No.	**Household composition in 1998**							**Members**	
	Male head	**Wives of head**	**Sons**	**Sons* remaining in household**	**Daughters**	**Daughters* remaining in household**	**Extended family** living in compound**	**Total**	**Current 1998**
1	1	2	4	3 (0)	4	2 (1)	1	12	9
2	1	2	3	1 (0)	3	1 (0)	0	9	5
3	1	2	4	4 (1)	13	13 (9)	8	28	28
4	1	1	4	4 (0)	2	2 (0)	0	8	8
5	1	1	5	5 (0)	3	2 (0)	0	10	9
6	1	1	4	3 (0)	5	3 (0)	0	11	8
7	1	1	2	2 (0)	4	4 (2)	0	8	8
8	1	2	2	2 (2)	2	2 (1)	0	7	7
9	1	1	3	3 (1)	3	3 (3)	0	8	8
10	1	1	5	5 (1)	5	5 (2)	2	14	14
11	1	2	3	2 (0)	4	2 (0)	0	10	7
12	1	2	2	2 (0)	5	3 (1)	0	9	8
13	1	1	1	1 (0)	0	0 (0)	0	3	3
14	1	1	5	2 (1)	1	1 (0)	0	8	5
15	1	1	2	1 (1)	1	1 (1)	1	6	5
16	1	2	3	2 (0)	1	1 (1)	0	7	5
17	1	3	3	3 (1)	8	8 (7)	2	17	17
18	1	2	2	2 (2)	5	5 (5)	0	10	10
19	1	2	3	2 ()	8	8 ()	0	14	14
20	1	2	4	4 (1)	6	6 (5)	2	15	15

(Source: own fieldwork)
* *Brackets indicate number of offspring 10 years old or under*
** *Elderly parents, in-laws or kin family*

4.4 The farming system

The low input - low output extensive farming system in Fandou Béri is typical of the region (Baidu-Forson and Williams, 1996). It combines cereals, legumes, livestock, and trees with the primary objective of spreading risk through diversification. The predominant cropping system is millet-based (*Pennisetum glacum* L.), the millet often being intercropped with cowpea (*Vigna unguiculata* (L.) Walp.). Millet is planted in low-density patterns, often at less than 5000 pockets per hectare (Bationo *et al.*, 1992). Other cash crops include groundnut, sorghum, sesame, hibiscus, gourds and okra. Cotton has not been grown in the village since the droughts in the 1980s[1].

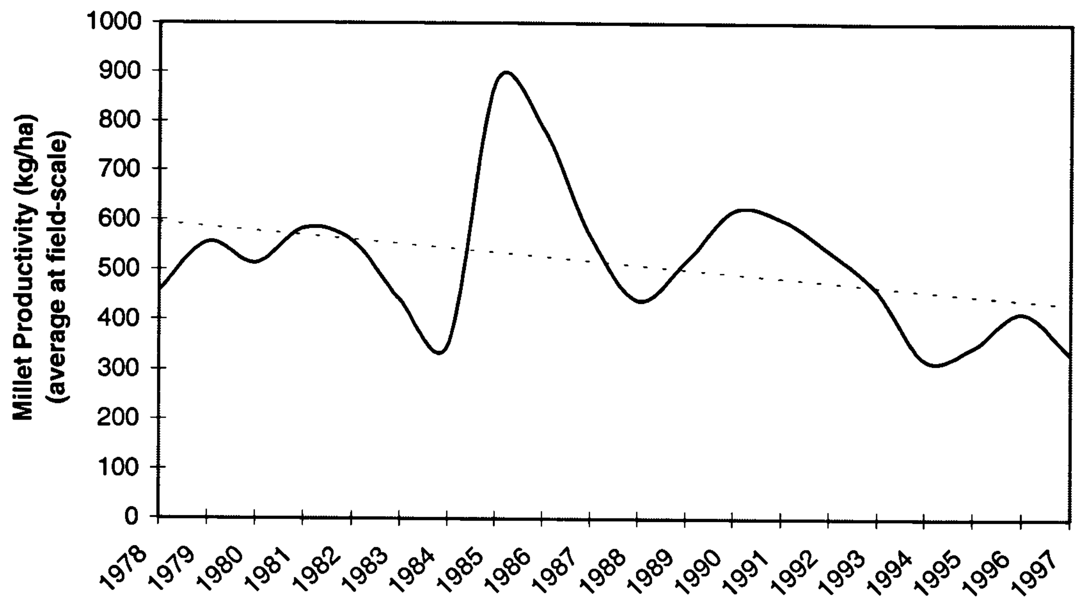
Millet yields rarely exceed 300kg per hectare and soil fertility in the region is perceived to be declining. However, as figure 4.4 shows, millet productivity is highly responsive to rainfall and while there appears to have been a decline in yields from 1978 to 1997, 1998 yields were high, contradicting the idea of a negative trend (see figure 7.4). Nevertheless, during the last twenty years the evidence is of slow degradation. While there is little use of improved seed varieties, pesticides, inorganic fertilisers or animal traction, organic manures can double yield with good rainfall (Gandah, 1999) as seen in the mid-1980s (figure 4.4). Animal manure and fallowing are the primary methods for soil fertility improvement, although composting, burning, mulching with crop residues and household waste are also used. The farmers operate a rotation system; part of each holding may be fallowed while another part is cultivated, or spatially segregated holdings may be rotated. The average fallow period is about 2 to 3 years. Women often cultivate small areas of the fallow land for cash crops and collect 'wild' sauce ingredients.

Households cultivate 2 to 10 hectares of land and most families have 2 to 3 fields. Boundaries between fields are delimited with trees or planted with grasses. Family members carry out most of the farm work. The peak periods of labour demand on the farm are between April (first rains) and October (harvest). Farming is labour-intensive and the production system has not changed significantly for several generations; low

[1] Farmers also find it difficult to make a profit from cotton production, following competition on the free market and the high costs of fertilisers brought about by Structural Adjustment Policies. Groundnut production has also fallen from the 1964 figure of 63% of exports by value (FAO, 2000).

technology manual work relies axes, machetes and various types of hoe. There are four ploughs in the village but their use is limited to the wealthier families.

Figure 4.4: Two decades of millet productivity in Fandou Béri (SERIDA data)



4.4.1 Livestock

All the sample households owned some livestock (cattle, goats, sheep, donkeys and chickens) (see appendix 1), although there are differences between Djerma and Fulani holdings (see table 4.4). The village chief also owns a horse although it is not kept in the village. Despite the rapidly fluctuating livestock market, the villagers consider livestock to be a good way to store wealth, while at the same time providing useful goods, such as milk and manure. Djerma keep smallstock within the compound, bringing them fodder from their fields, and sometimes corralling the animals on the fields. Donkeys are used for transporting manure and household waste from the compound to the field. Fulani have developed a more intensive farming system than the Djerma, which is more deeply dependent on inputs of animal manure. Fulani families in Fandou Béri own up to 50 head of cattle, although not all these animals remain in the village for the entire year.

Table 4.4: Livestock holdings of sample households (source: own data, SERIDA)

	% Composition of livestock holding				
	Cattle	**Horses**	**Small ruminants**	**Donkeys**	**Chickens**
Djerma	19	<1	32	3	46
Fulani	39	0	42	6	19

A transhumance route delineates the administrative boundary between Fandou Béri and Dantiandou to the east. Fulani use the route to move livestock to better grazing lands in the south (such as Benin and Togo) at the end of the wet season and to the north (such as Mali and northern Niger) at the end of the dry season. Resident Fulani herds are corralled close to compounds at night during the dry season and moved to fallow areas or grassland on the plateau during the growing season. Djerma usually entrust their cattle to Fulani herders who keep the livestock away from the cultivated fields during the growing season and bring the herd back after harvest to graze on the crop residues on the owner's fields. This exchange arrangement often requires payment. Exchange arrangements have become more difficult for Djerma because fewer herds pass through the village. This may be due to less fallow land in the village or to the increased harvest of crop residues for fodder use in the village.

4.4.2 Market opportunities and off-farm work

For heads of household the main production objective is to meet household food needs. Any surplus is sold in local markets. Households also sell or exchange other natural resource (NR) products (such as firewood, 'wild' plants, domestic goods, construction materials) in local markets. Non-NR products are also sold, such as animals, animal products, food products, domestic goods, paraffin or cigarettes. Home-based commercially- activities are popular with women, who derive income from the sale of prepared food, petty trading and wild plants for medicine and cooking which they collect. Other home-based activities include mat making, the sale of animal fodder, fetching water and raising animals. Fandou Béri has its own small market and daily markets occur within a day's walk from the village. The nearest livestock markets are at Hamdallayé (16km) and Dantiandou (25km) and from Hamdallayé the bus or a bush taxi can be used to reach Niamey (50km). Niamey exerts a noticeable influence on economic and social life. The capital is a source of off-farm work or trade. The Club du Sahel (1995) predicted that the economies of urban hinterland areas in West Africa (including Fandou Béri) would become increasingly influenced by the rapid growth in urban markets over the next decade.

During the dry season, when there is less need to work on the farm, some household heads undertake migrant work to seek cash. Money that is earned, often from headloading of textiles, manual labour or selling goods, is usually sent back to the household to buy food or to invest in livestock. Older men travel to the rural Ivory Coast where people from Fandou Béri have established social networks, while many younger men choose to travel to Niamey and other parts of Niger, Nigeria, Benin and Togo. However, migration is not always lucrative and its returns do not always find their way into the household budget. Most significantly, migrant work is undertaken for many different reasons, not just as a 'coping strategy', and is seen by some as an investment. For those with religious training, it is possible to travel on 'maraboutage' to give Islamic prophecy and healing for cash. The migrant movement of workers during the dry season elsewhere in West Africa has been ascribed symbolic as well as economic value (Rouch, 1956; Painter, 1987; Scoones and Toulmin, 1999a; Rain, 1999).

4.4.3 Development interventions in Fandou Béri

In terms of development interventions to aid agriculture, the village received limited support in the 1960s under the *animation rurale* initiatives of President Diori and President Kountché (Stoller, 1995:147). More important were the opening of the village market in 1973 and the local Seed Multiplication Project (1979-1987). The Seed Multiplication Project (run on the FAO model, with Peace Corps support from Hamdallayé) offered technical information, improved millet varieties, and subsidised fertilisers and pesticides. The project purchased millet crops from farmers at above market prices. The scheme also raised farmers' awareness of the benefits from using fertiliser.

Since the programme ended, farmers have found it difficult to afford fertilisers, especially after the abolition of subsidies in 1994. Devaluation of the franc CFA (the monetary currency for West Africa) in 1994 pushed the costs of farm inputs up further. Droughts in recent years have also reduced the benefits from using fertilisers.

Likewise the high cost of liming soil means that farmers benefit little from this means of reduced soil acidity. However, the seed multiplication project left a legacy in attitudes and many farmers remember it fondly. Only four farmers were able to purchase improved crop cultivars from a Hamdallayé co-operative in 1997, and all later reported poor harvests due to low rainfall and insect attack.

A second scheme ran during the same period as the seed programme. It was a small Peace Corps initiative involving dry season irrigation for vegetable production. It was started with women, but it was quickly abandoned. Farmers are inclined to dismiss other fertility-restoring techniques such as the use of compost pits and stone bunding as unworkable or too difficult, when compared to adding fertilisers.

In 1998, a cattle credit scheme was established by the SERIDA Project, which gave women in the village the opportunity to invest in livestock rearing. Profits have most frequently been reinvested in smallstock breeding. No government extension services and no external agencies currently operate in the area, although farmers are able to receive radio broadcasts on agricultural issues and are exposed to new technologies during their travels.

4.5 Land degradation, conservation and land-use change

Complex local patterns of erosion and general rates of soil loss of 40 t ha^{-1} yr^{-1} over a 30-year period were found by Chappell (1995). The significance of these high rates is debatable (Warren *et al.*, 2001). Soil erosion removes nutrients, increases surface crusting and decreases soil depth, thus potentially decreasing the water-holding capacity, which could be a critical factor. However, it may take many decades before the soil productive capacity is reduced by erosion in this way (Larson *et al.*, 1983; Olofin, 1992). This may explain why, despite evidence of erosion, there is little intensive conservation work in the village. Moreover, the current economic situation for most farmers' offers few short-term benefits from cash and labour investments in intensive conservation.

Manu *et al.* (1994) claimed that farmers did not recognise a relationship between erosion and the loss of vegetative cover, arguing that farmers attributed poor soil fertility to drought, a lack of external inputs and increasingly intensive use of land. This interpretation confuses local perceptions of erosion and fertility and therefore misses the point that farmers view the impact of rainfall on soil fertility as of more importance to crop growth than that of soil erosion. Moreover, the demand for fertilisers for intensive management indicates the legacy of the intervention projects in the village but also that busy farmers may tell researchers what it is believed they expect to hear (Stoller, 1989).

In fact, farmers in the village do take less intensive measures to protect their soils (Allan, 1997). Fallow rotation, vegetation maintenance and mulching (for example with millet stalks) reduces wind erosion and rejuvenates degraded land by accumulating windblown soil and encouraging termites (to ameliorate surface crusting) (Drees *et al.*, 1994; Wezel and Boecker, 1999). Livestock is also managed to minimise degradation (Casenave and Valentin, 1989; Hiernaux *et al.*, 1999). These issues are discussed further in Chapter Five.

Furthermore, social changes have also been important in shaping the landscape. A pattern of expansion and intensification has taken place in the village territory over the last fifty years (Batterbury *et al.* 1999). The pattern is similar to those observed elsewhere in the region (Heasley and Delehanty, 1996; Amissah-Arthur *et al.*, 2000). The fallow period has shortened from ten years a decade ago to a rotation cycle of two or three years today (Osbahr, 1997). Population growth, increasing farm fragmentation and subdivision[2], tenure insecurity, labour shortages and risk minimisation are some reasons for the changes.

Families spread risk over a large farm area to capture some of the highly spatially variable rainfall and soil types. 'Extensive' management is effective when a

[2] Fragmentation describes the situation in which a farmer's holding consists of several non-contiguous parcels. The economic objective is to have one large holding since this reduces costs to labour and other inefficiencies (Bruce, 1993). However high microvariability means fragmentation reduces risk. Subdivision describes the process by which a single parcel of land is progressively subdivided, sometimes into awkwardly small pieces. Excessive subdivision is the result of too many farmers working too little land. Islamic inheritance laws create subdivision (land is inherited and divided individually by sons).

household has labour shortages, because fallow rotation is the most economical use when labour is short. However, since the 1960s large family fields have become subdivided and smaller individual holdings have emerged as Islamic inheritance systems have been adopted. One informal arrangement for families without enough land to meet their own household needs is to practice sharecropping. Since land cannot be bought or sold, the sharecropper borrows land from other farmers but must give a gift to the owner in exchange. However, with no written agreement between the owner and the tenant, there is little incentive to invest in conserving or improving the borrowed field. Issues of tenure are discussed in Chapter Seven.

Social tensions have also influenced land use. Fandou Béri has been locked into a long-running dispute over land rights with the village of Kallassi to the west. It became so serious in the 1950s (with a number of fatalities) that the government become involved, imposing a boundary to the territory. This boundary continues to be disputed: farmers from Fandou Béri still claim fields in Kallassi territory. On several occasions the *Chef du Canton* in Hamdallayé has had to settle disputes over inherited fields. Serious disputes have continued to the present and the land rights to the east remain unclear (Batterbury *et al.*, 1999).

Negotiated solutions to land conflicts have been made more difficult by national land legislation that established tenants' right to land. The 1992 Rural Code requires land to be transferred to another household if it remains unused for periods over three years (Lund 1998). Lavigne Delville (1999) claimed this encouraged families to use as much of their land as they had labour to do so and deterred the use of long-fallow periods or the lending of land. Conflicts have arisen in the village over land rights after long-term leases, suggesting that land pressure is becoming an increasingly important issue in Fandou Béri.

4.6 Specific indigenous knowledge in Fandou Béri

Local knowledge is learned through experience, practice, travel and social networks and it is inherited (Chambers, 1997). The farmers in Fandou Béri possess detailed environmental knowledge, as well as an understanding of physical and biological processes, of cultivation histories and local land and soil classification systems. There have been several studies of soil knowledge in the Sahel, which have examined ethnopedologies as part of wider investigations into local land management. The concepts in local knowledge are reviewed in Chapter Two (section 2.3.2). Studies of the ethnopedologies of the Djerma (Taylor-Powell *et al.*, 1991a; Manu *et al.*, 1991; 1996; de Groot, 1995; Allan, 1997) and Fulani (Lamers and Feil, 1995; Krogh and Paarup-Laursen, 1997) have found many common definitions and classifications in indigenous knowledge systems in the region (table 4.5). These indigenous taxonomies include distinct categories and understandings for land type, soil fertility, moisture retention capacity, soil texture, structure, colour and erosion processes. The three main classes of soil (*tassi*, *botogo* and *gangani*) are divided into further classes based on landform, surface crusting, colour, texture and land-use history.

The most important aspect of local soil knowledge is that the typologies are relative and site-specific rather than absolute and universal; like most other indigenous soil typologies it is oriented towards practice and land management (Sikana, 1993). Environmental characteristics are important in farmers' understandings of soil fertility in Fandou Béri and the local classification of soils is closely related to soil moisture and rainfall (Allan, 1997).

As discussed in the review in Chapter Two, one of the qualities of agricultural management in diverse and risk-prone environments is the use of detailed agroecological knowledge in exploiting what Chambers (1989) refers to as 'micro-environments'. For example, farmers in Fandou Béri possess complex ethnobotanical knowledge and use many species associations as indicators of soil properties, in particular soil fertility (Osbahr, 1997). Farmers can use their specific knowledge to manage dynamic patterns of micro-variability under limited resources, and adapt to dynamic patterns with experimentation using specific knowledge. Furthermore, villagers held detailed knowledge of plants and trees for medicinal and cooking purposes and this was partially documented by SERIDA (Batterbury and Longbottom, 1996).

Table 4.5: Comparison of local soil definitions in Taylor-Powell et al. (1991a), de Groot (1995) and Allan (1997) (see Osbahr and Allan, forthcoming)

Djerma Term	Recorded by Taylor-Powell *et al.* (1991a) in region	Recorded by Allan (1997) in Fandou Béri
Giro	Valley floor / gully / low lying land	*Gangani* (hard, clay soil) combined with rocks (1)[a].
Fondu	Upland less fertile mounds soil	Equivalent to *Fandu* (de Groot, 1995) and Fandou of the village name meaning: sandy hill (3).
Tondo Bon	Plateau, non-arable	Area of small rocks on a hill or rise e.g.: plateau to north of village (3).
Tondo Kakasia	Land just below plateau, stony and unproductive	Area with small rocks on the surface but not necessarily associated with a plateau (3).
Sacara	1st year of cultivation	same meaning (4).
Lalibanda	2nd year of cultivation	same meaning (4).
Kwar kwari	field in cultivation for 3-4 years	3 rd year of cultivation (4).
Blanga	field cultivated for 5 or more years	Equivalent to *Balanga* (de Groot, 1995) or *Boulougu*, meaning: a poor tassi (sandy) soil tired after years of cultivation (4).
Farezenon	fallow	An area that has been abandoned to bush (i.e.: not fallow in the sense of reserved for future use or being rested to restore fertility).

[a] Numbers in brackets refer to the number of groups which gave each definition of the term; four groups were asked for definitions and a number less than 4 occurs where groups were unfamiliar with the term.

Djerma Soil Name	de Groot (1995)		Allan (1997)
	Village: Samari	**Village: Babangata**	**Village: Fandou Béri**
Gangani	Hard soil without vegetation, not cultivated	Clay, hard, red, without vegetation	[a] Hard clay soil, difficult to plough. Also the small patches of hard crusted soil in otherwise sandy fields.
Tombo	Dark red, large grained sand; bad grasses present	Dark fertile soil associated with old settlements	[a] A dark coloured and very fertile soil: a clay '*botogo*' type soil (mentioned by group F13 only). [b] Very fertile soil; name of area around Chief's compound (4); associated with an old village site (2).
Fandu	The place which does not hold water, sandy and infertile, fine grains		[b] Has same meaning as 'Fandou' of village name: small sandy hill (4).
Gorou	Clay covering sand, in the depressions, where water passes	Clay, hard, where water passes	[b] Water route (4).
Koubou	Named after a tree (*Combretum micranthum*) which is common here		[a] A type of tree associated with the hard soils in the north of the territory and also the *korabanda* area (3). [b] A type of tree (4) associated with hard areas (*gangani* and *botogo*) (2).
Balanga	Sandy soil, black, fine grained, very infertile	Soil tired after several years of cultivation, infertile, sandy	[a] Has the same meaning as *Boulougu*: tired sandy soil giving poor yields (1). [b] Poor *tassi* (sandy) soil, tired after years of cultivation (4).
Bagou		Clay, hard, where water stagnates	[a] Same soil as *botogo* (clay) but with lots of trees (3); where water runs over a clay soil (1). [b] A place within a hard clay soil area which has lots of trees (4).

[a] Definitions given without prompting during individual or group discussions; numbers in bracket refer to the number of individuals/groups which gave each definition of the term.
[b] Definitions given in response to direct question on the meaning of each term (four groups were directly questioned); numbers in brackets as before.

Ethnicity, often associated with occupational specialisation (e.g. herding or agriculture) contributes to some of the most pronounced forms of social division within the village. It can be seen significantly to affect the differentiation in individual knowledge, cosmologies and local information exchange (Osbahr, 1997; Simpson, 1999). For example, Fulani in Fandou Béri are entrusted exclusively with the care and management of Djerma livestock (a major form of investment) because of their unquestioned superiority of their animal husbandry knowledge (McCorkle and Bazalar, 1996).

5
Personal narratives

Many authorities have argued that land-users themselves should set the agenda for development, and that direct attention needs to be paid at this level to the concept of sustainable rural livelihoods (Chambers, 1997; Adams, 1990). The question is whether the narrative of agricultural crisis reflects reality or whether it is a reflection of a lack of understanding of local knowledge. Chapter Two found differentiated management to be a key reason why case studies often reached different conclusions about nutrient budget studies yet management is difficult to understand, let alone model. To understand issues of land allocation and soil fertility management in rural Sahelian villages, local perceptions of change, choices and priorities need to be explored in detail. This chapter begins the story of the complex relationship between rural dwellers' livelihoods and their soil management by an intra-household analysis in Fandou Béri, in an attempt to move beyond simplifications about 'typical rural smallholders' and 'typical rural households'. The discussion is primarily based on personal stories from the twenty sample households. The presented information includes extracts from transcriptions of in-depth discussions, visualisation mapping, survey data and questionnaire data.

The personal stories focus on the rainy season, known in Djerma as *kaydea waate*, because it is central to subsistence farming practice in the Sahel. While attempting to sustain their livelihoods, villagers in Fandou Béri face an uncertainty that begins with the rainfall characteristics. Therefore, the complexity within the study households' farming practice is firstly introduced through the agricultural cycle. The complexity is a result of the flexibility with which farmers negotiate the rains.

Second, farmers' perceptions of farmland and soil fertility change are presented. Local perceptions are compared throughout to the agricultural science literature. The farmers' local knowledge that is used to identify these changes, and known in Djerma as *berey*, is also explored. Third, the ways in which the farmers used this local knowledge to manage soil fertility are discussed. Extracts from interviews with each farmer are presented to show the diversity of local practices for managing nutrient inputs, outputs and recycling at farm-, field- and plot-scale. The focus on local theories and dynamics should provide insights into the relationship between IK, soil fertility and intensification.

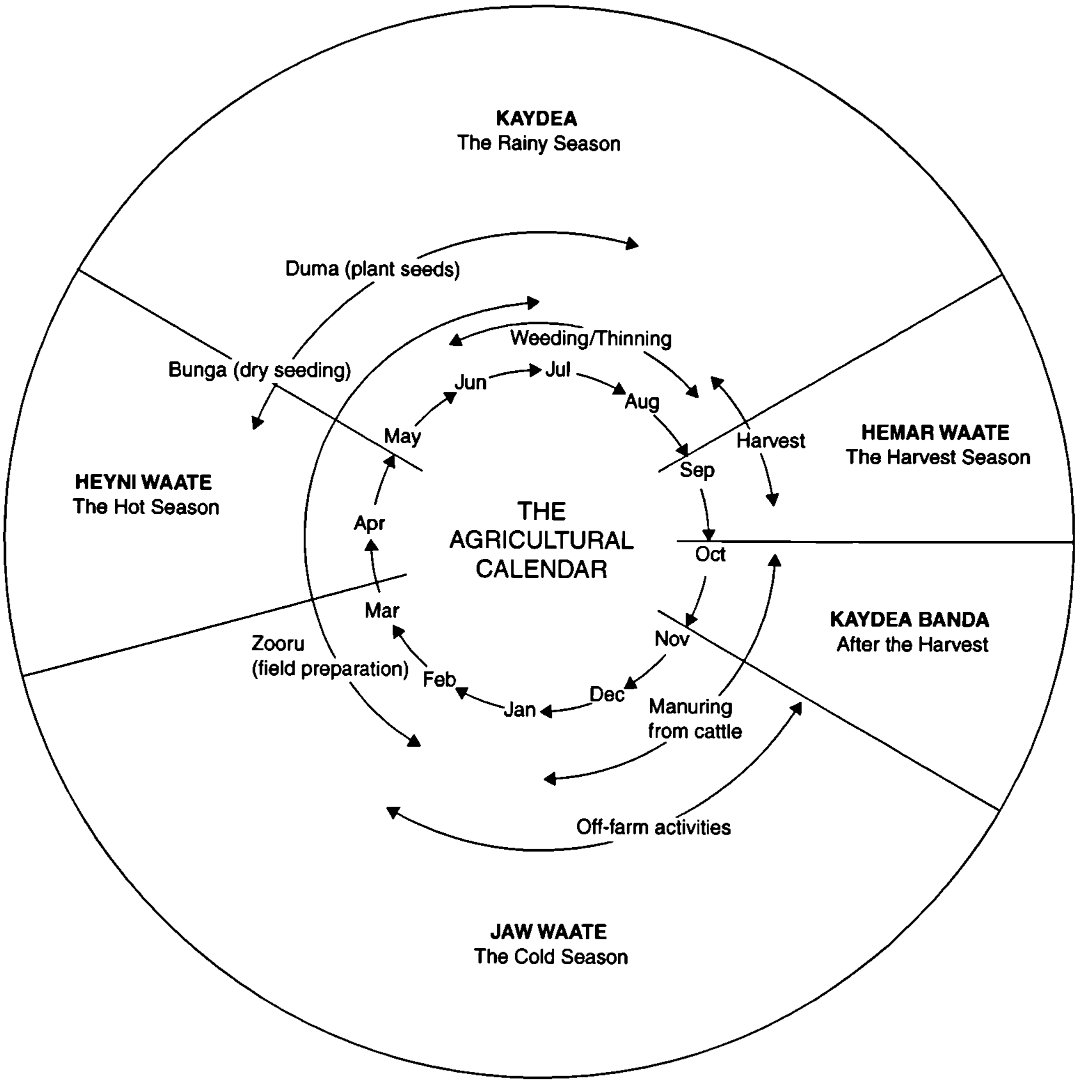
Finally, farmers' perceptions of the process of choice and prioritisation for natural resource management are examined. The influence of household 'capital' endowments is discussed. To illustrate the farmers' perceptions, case studies for each individual farmer are presented and the process is 'mapped' to explore everyday choice, experience and knowledge. 'Mapping' provides a reflection of farmers' own perceptions of household endowments and is used to understand their soil fertility investment and natural resource allocation decisions. Furthermore, their perceptions of farm constraints and opportunities provide an insight into the relationship between household 'capital' endowment and prioritisation.

5.1 The agricultural calendar and the importance of *Kadyea* (the rainy season)

Work on the farm is dependent on the variability of the environment. Farmers' decisions about farm activities need to be flexible and to exploit the resultant pattern of variability. Decisions about the level of investment of labour and other resources, and the land use are based primarily on the rains and the different stages of crop development. The rains dictate the farming year, the timing of key agricultural activities and the calendar for households in Fandou Béri (figure 5.1). The year's activities begin at the end of the harvest.

The farm calendar consists of four major tasks: field preparation before the rainy season, the planting of crops at the first rains, weeding and thinning plants competing with the crop mid-season, and the harvest. Each requires the farmer to make choices, but this study focuses on the first three tasks because it is during these tasks that farmers make decisions about the land use and soil investment.

Figure 5.1: The Agricultural Calendar at Fandou Béri



- *Kaydea banda*

  After the harvest of rainy season crops in October the first preparation tasks take place. Most crop stalks remain on the field (*fari*) after the grain heads have been cut. Some of these crop residues are removed from the field for domestic uses, such as fencing, to repair granaries or to burn as a fuel. Some are cut and stored as fodder for animals kept within the household compound. Only when the residues are left on the field to decompose are nutrients recycled back into the soil (*labu*) (unless manure from stabled animals is transported to the field).

Nutrients can be directly cycled back into the soil when corralled household livestock or other households' livestock graze residues (box 5.1). Djerma farmers encourage local Fulani to graze their cattle and smallstock herds on the crop residues from after harvest (box 5.1). Exchange arrangements between Djerma and Fulani appear now to be less symbiotic than they were some years ago, because herders are demanding cash payments (box 5.1). Grazing animals on the crop residues is considered particularly important by farmers for improving the organic matter content of *tassi* and the structure of *gangani*. Grazing on *botogo* and *bongu* (marshy soils in the rainy season) is considered less important. Farmers try to prioritise grazing to areas that need the greatest improvement, an investment for the season's harvest. *Kaydea banda* is also a time when choices are made about land uses in the New Year. Areas that have produced poor yields, where indicators of poor soil have developed (see section 5.2.2.1), or where new gully erosion (*gooru*) has appeared are all designated to be put into short-fallow.

BOX 5.1: GRAZING ARRANGEMENTS FOR DRY SEASON SOIL IMPROVEMENT

Farmers claimed that their best opportunities for dry season soil improvement came from nutrient inputs from livestock grazing crop residues and fallow. The following statements describe arrangements, which range from 'free' inputs from passing animals, through inputs from family and friends' animals or the farmer's own animals, to inputs from paid exchange contracts with local Fulani. It is unusual for manure from stabled animals within the compound to be transported to the field until *Jaw waate*.

Inputs from household animals:

- *Hassane Malam*: "I used my donkeys to manure my *tassi* field nearest to the village last year [1997]. They were kept on the field during the day to eat the plants. My children looked after them while they were on the field".
- *Mounkaila Djibo*: "I have some goats and sheep (9 animals) which were corralled on the fallow part of the field in December (1997). They spent the late evenings on the fallow. After that, I hobbled the animals at night on the field. The part where the animals were, was the part that I cleared this year (1998) [to cultivate] because I think it will be better soil now".
- *Amadou Soumana* (Fulani): "The cattle stay close to the house during the evenings and at night. This way we see they are alright. They also fertilise our field and it is much better ".
- *Marou Soumana* (Fulani): 'I corralled my cattle that I kept here [not away on transhumance] on the entire field [cultivated and fallow]. I need to use all the land because there are many animals.

They do not all stay on the fallow during the rainy season because there are too many. Some graze on my neighbours' fallow. I also care for some Djerma animals which stay on the farm and these help the life in the soil".

- *Saley Moussa* (Fulani): "I like to keep the cattle on the cultivated part of the field for most of the dry season except after sowing cowpeas. Not all my animals are here during the dry season. Those that are here are not allowed on the fallow during this time because they eat too many of the bushes. If there is not enough fodder they are moved to nearby rangeland or if people want them to eat their bushes. I just penned some of the animals in a place near the edge of the farm where the millet growth was very poor last year".

Inputs from corralling exchange without cash payment:

- *Adamou Garba*: "I had Fulani animals on my *tassi* field for two months after the harvest in 1997. They ate all the crop residues and rested on the fallow there. It was convenient for them because the field is near the Fulani huts".
- *Moussa Soumana*: "I had a 'gift' of manuring from the animals of my relatives for my *tassi* field. A few goats and sheep were corralled on my two-year old fallow over the dry season [1997/98]. I would like to do the same again at the end of this season because then this field would be ready to cultivate in 1999".

Inputs from corralling exchange with cash payment:

- *Hamani Salifou*: "I paid some Fulani [in the village] 1250 f CFA and 8000 f CFA for two months on my *tassi* field'.
- *Soumana Adamou*: "I paid some Fulani herders 2500 f CFA to graze the crop residues for 1½ months. Some of the cattle belong to me. I think that to corrall cattle is best, but they are often away with the Fulani so I corralled the small animals, which my wife keeps most of the time in the household. She sells them. They ate leaves on five-year old fallow on my best *tassi* field. The one near to the village. This field gets the best inputs [from grazing]. It is in fallow rotation in a small part. But the cost of making an arrangement is more expensive now and cash is difficult".

- *Jaw waate*

During the dry season from November to February, known to farmers as the 'cold season', families are able to find time to undertake a greater number of off-farm activities. These activities provide essential cash income, to buy food, repay debts, support extended family and buy grain to plant. This is the time when men in the household can leave to search for work or trade in the capital, Niamey, or further away. The role of off-farm activities and the informal sector on agricultural decisions is explored further in Chapter Seven (section 7.3). There is a little dry season gardening of cassava and some vegetables but limited water supply and the labour costs restrict the activity. Any work that does take place on the farm during this season is limited to transporting manure from the compound to the fields. If farmers do not own many livestock and fail to make arrangements with pastoralists they are dependent on carrying manure in baskets from the homestead to the field and distributing it by hand to selected areas, which is time-consuming if the household does not own a donkey or cart. By February most men have returned home to begin to prepare the farm and wait for the rains (box 5.2). This is a time of hardship for most households as the food from the previous harvest begins to run out and granaries empty and fall into disrepair. For many, the selling of assets such as small livestock is essential if they are to have enough food at this time.

BOX 5.2: WHEN TO PREPARE?

Adamou Garba can only start his field preparation after he has returned in February from working in the Ivory Coast. He claims this is a good time to start work on the farm because the weather is windy and cool so he does not have to suffer the heat. He starts work on his *tassi* field first, cutting and burning the regrowing bushes, and only when this field is prepared does he begin to work on his *botogo* field. In April the wind changes direction across the village and he knows that work must soon be completed because small clouds begin appear in the sky. The sky becomes hazy and grey before the storms and the buds on the *Korkorbey* tree (*Combretum glutinosum*) begin to show. He knows that it will soon rain and the work on the *botogo* should be completed when the *Deli-gna* and *Louley* plants begin to show their leaves.

- *Heyni waate*

  Although land clearance in preparation for planting is started in the cool month of February, *zooru* (field preparation) often continues into the hot season of April and May. Many decisions now need to be made about where to prepare and where to leave land in fallow. Even the parts of the fields that were cultivated the year before have to be cleared completely and new areas that have been in rest will require even more work. Bushes are cut back with machetes and small hoes (*kalma*) are used to remove the stumps. Sometimes these bushes, along with the remaining millet stalks, are burned to release nutrients. Ploughing is not common, but farmers do mix manure into the soil using short hoes. As the rainy season approaches a few farmers may risk *bunga* (dry-seeding) if they feel they can predict early rain storms. Dry-planting risks losing the seed but to miss the first nitrogen flush is to risk poor growth later. By February farmers claim that deciduous trees can anticipate the slight lengthening of the days and leaves begin to bud, indicating the coming of the rains.

- *Kaydea waate*

  The end of April to September is the time of year that requires the most work on the farm. This period is the main part of the rainy season, although rains can continue into October. Farmers have to anticipate the rains and quickly turn out all available labour in the few days after the first heavy showers. The transition from dry conditions to a soil that is sufficiently wet to stimulate germination and support seedling growth normally occurs abruptly following the first storm. Timely planting strategies are critical to the success of the crops, and farmers must decide when to plant, immediately before or after the first rainfall events (box 5.3). Farmers use a 'hand measure' or '*sumbu kambe fatta kuyan labu ra*' to know when the rain has been sufficient for germinating the seeds (box 5.3). This 'hand measure' is considered a reliable measure, although some farmers claim that they do not consider planting until after a 15mm rainfall event for *tassi* soil and more on silty soils. False starts to the rainy season place a heavy demand on farmers and their families at a difficult time of the year. They must make repeated efforts to plant until all the stands have seedlings.

BOX 5.3: WHEN TO PLANT?

Kadri Yayé describes how he and his friends know when to plant the crops:

"When it has rained you must go straight to your fields. I go to my nearest *tassi* field. I can tell that the soil is ready to sow when it is hot and damp. We use a hand measure. It measures how much of the topsoil is wet and tells you if you can plant millet, or even your sorghum and beans. But to plant your entire field and other crops you need many labourers. The hand measure is simple. You put your fingers straight into the sand and then estimate the depth of the soil moisture. If the topsoil is wet to a depth reaching between all your fingers and the thumb then you should plant quickly, if you have some help. If the soil is not this wet then you must wait for the next rainfall event. If you do plant, you cannot always tell that it will rain again in a week. Sometimes I take a hand measure after I have planted some grain and the soil is very dry. Then I know that I will need to plant the seed again. This is very difficult for me as I usually have very little grain and have to buy more. If I plant before the first rains, the small clouds in the sky tell me that it may rain in the afternoon or the next day and the winds in the village change direction more often".

Duma (sowing) is labour-intensive. The farmer has to decide exactly which part of the field he will plant first and dig holes for the grain with a *kalma*, pacing them out over the cleared area. Often it is the children who follow after him, placing the grain in the hole and concealing it in the soil with their feet. If the farmer has not had time to clear the entire field intended for cultivation, crops are planted in the unprepared soil. Attention is directed towards *tassi* fields for the first seeding and later in the season, if the rains are sufficient, towards *botogo* and *gangani*. The timing of these tasks reflects the growth cycles of the major crops (fast growing 100-day millet (*Heyni ciri*), 120-day late millet (*sumno*) and sorghum (*hamo*), 90-day and 120-day beans (*dunguri*), and 120-day groundnut (*damsi*). The timing of the planting also reflects the priority given to pearl millet (*Heyni*). Box 5.4 illustrates the complexity of the planting strategies for farmers in the study.

Box 5.4, furthermore shows that farmers construct a dense geometry of inter-planted crop mixtures as a way of controlling weed growth later in the season to save labour. Crops that make complementary nutrient niche demands are planted together. The plants' soil moisture and nutrient requirements are also reflected in the intercrop pattern and influence the type of soil they are can be grown on. These patterns changed as farmers experiment or adjust to different soils and crops. For example, farmers described how they planted sorghum and sesame on more silty soils (box 5.4). Inter-planting can continue through the season if a favourable rainfall distribution provides enough residual moisture to support maturing crops. Beans/cowpea (*dunguri*), groundnuts (*damsi*), sesame (*lampti*) and hibiscus or sorrel (*jisima*) are planted after the main cereal crops. Women often cultivate a small area of the fallow portion of the field to grow crops for use in cooking or to sell at market.

BOX 5.4: DIVERSITY IN INTERPLANTING PATTERNS

Far from each farmer following the same planting strategy, there are significant differences between the individual inter-planting patterns, as the table below shows. The crop-planting densities are given as the distance (in paces) between plants (in the same row) and by the distance between the different rows. 60% of farmers varied the planting densities according to the perceived fertility of the soil, making use of spatial variations in soil type. In addition, farmers planted with the greatest distance between millet plants for *tassi* soils (1-1.5 paces) and the smallest distance for *gangani* and *botogo* (average 0.5-1 paces). Intercropping and crop sequencing (crop rotation) were described as providing different plants with different needs and these could be met by understanding the changing spatial variation in soil fertility. The benefits of crop rotation have been shown by Sauerborn *et al.* (2000).

Farmer	Millet	Cowpea	Sorghum	Peanut	Sesame	Hibiscus	Varies*
1	1.0 x 1.0	2.0 x 2.0	1.0 x 1.0	0.4 x 0.6	0.5 x 0.5	1.5 x 1.0	No
2	1.2 x 1.2	2.0 x 2.0	N/A	N/A	N/A	N/A	No
3	1.0 x 1.0	2.0 x 2.0	1.0 x 1.0	0.4 x 6.0	1.0 x 1.0	1.0 x 1.0	No
4	1.2 x 1.2	2.0 x 2.0	1.5 x 1.0	N/A	N/A	1.0 x 2.0	Yes
5	1.0 x 1.0	1.5 x 1.0	0.8 x 0.8	0.2 x 0.5	N/A	1.0 x 2.0	Yes
6	1.0 x 1.0	1.5 x 1.5	0.8 x 0.8	0.4 x 0.6	N/A	Borders	Yes
7	1.3 x 1.3	3.0 x 3.0	0.8 x 0.8	0.2 x 0.2	0.8 x 0.8	Borders	Yes
8	1.0 x 1.0	2.0 x 3.0	0.5 x 0.5	0.2 x 0.4	N/A	Borders	Yes
9	1.0 x 1.0	2.0 x 0.2	0.8 x 0.8	1.0 x 0.6	N/A	1.0 x 1.0	Yes
10	1.0 x 1.0	2.0 x 2.0	0.8 x 0.8	0.2 x 0.2	1.0 x 1.0	1.0 x 2.0	No
11	1.2 x 1.2	2.0 x 2.0	0.8 x 0.8	0.3 x 0.3	0.4 x 0.4	1.0 x 1.0	No
12	1.0 x 1.0	1.5 x 2.0	0.8 x 0.8	0.2 x 0.2	0.8 x 0.8	1.0 x 1.0	Yes
13	1.4 x 1.4	1.5 x 2.0	0.8 x 0.8	0.2 x 0.2	0.2 x 0.4	N/A	Yes
14	1.0 x 1.0	2.0 x 2.0	0.8 x 0.8	0.2 x 0.2	N/A	0.8 x 0.8	No
15	1.0 x 1.0	2.0 x 2.0	0.8 x 0.8	N/A	N/A	Borders	Yes
16	1.0 x 1.0	3.0 x 6.0	1.0 x 1.0	N/A	N/A	1.0 x 1.0	No
17	1.0 x 1.0	2.0 x 2.0	1.4 x 1.4	0.2 x 0.2	1.4 x 1.4	2.0 x 4.0	Yes
18	2.0 x 2.0	2.0 x 2.0	1.4 x 1.4	0.2 x 0.2	0.2 x 0.4	1.0 x 1.0	Yes
19	1.0 x 1.0	2.0 x 1.5	0.8 x 0.8	0.2 x 0.2	0.5 x 0.5	0.8 x 0.8	No
20	1.5 x 1.5	2.0 x 2.0	0.8 x 0.8	0.8 x 0.8	N/A	Borders	Yes

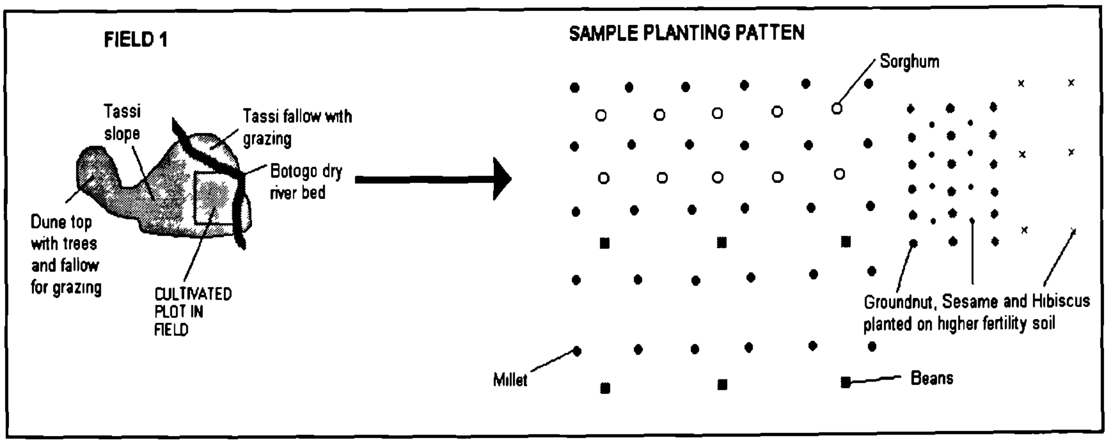
* *Farmer considers difference in soil variation within a field in his planting pattern*

Farmers planted the crops at different times, reducing the risk of labour bottlenecks and because local millet cultivars will survive early-season droughts whereas other crops will not. The main cereal crop, millet, is planting just before or immediately after the first rainfall event. A table giving each farmer's average planting calendar for other popular crops is shown below. The table refers to the number of days after planting the millet grain.

Farmer number	Cowpea	Sorghum	Peanut	Sesame	Hibiscus
1	20 days	0 days	15 days	15 days	30 days
2	14 days	N/A	N/A	N/A	N/A
3	20 days	30 days	30 days	30 days	25 days
4	15 days	15 days	N/A	N/A	15 days
5	14 days	5 days	20 days	N/A	20 days
6	20 days	15 days	30 days	N/A	20 days
7	20 days	15 days	30 days	15 days	20 days

8	20 days	10 days	30 days	N/A	20 days
9	14 days	0 days	15 days	7 days	30 days
10	20 days	15 days	10 days	0 days	14 days
11	30 days	25 days	30 days	7 days	N/A
12	25 days	2^{nd} rain	30 days	7 days	25 days
13	15 days	7 days	20 days	N/A	20 days
14	15 days	15 days	20 days	N/A	17 days
15	15 days	10 days	N/A	N/A	18 days
16	7 days	7 days	N/A	N/A	2 weeks
17	7 days	2 days	15 days	10 days	15 days
18	30 days	1 days	30 days	30 days	20 days
19	20 days	15 days	17 days	17 days	15 days
20	3^{rd} rain	30 days	30 days	N/A	30 days

There is a continuous innovative process to the planting of the crops, adapting to the environment, changing rainfall and resources available to the farmer and to pest outbreak (using intercropping and biodiversity management, see Abate *et al.*, 2000). Some farmers saw this as part of the cropping system, while others like Kadri Yaye saw the 'learning by doing' process as experimentation (albeit as a complex practice). An example of the intercropping pattern for one of Kadri Yaye's fields is shown below:



Meanwhile, tasks such as uprooting regenerating shrubs and clearing ever-larger areas of the field may continue. Although farmers considered manure distribution before the rains to be the better practice, fertilisation with transported manure often continues into the growing season. If farmers can afford small quantities of inorganic fertiliser, such as NPK, it is placed around individual plants. Animals are restricted to fallow areas after the planting of beans because the young seedlings do not recover from damage if grazed (box 5.5).

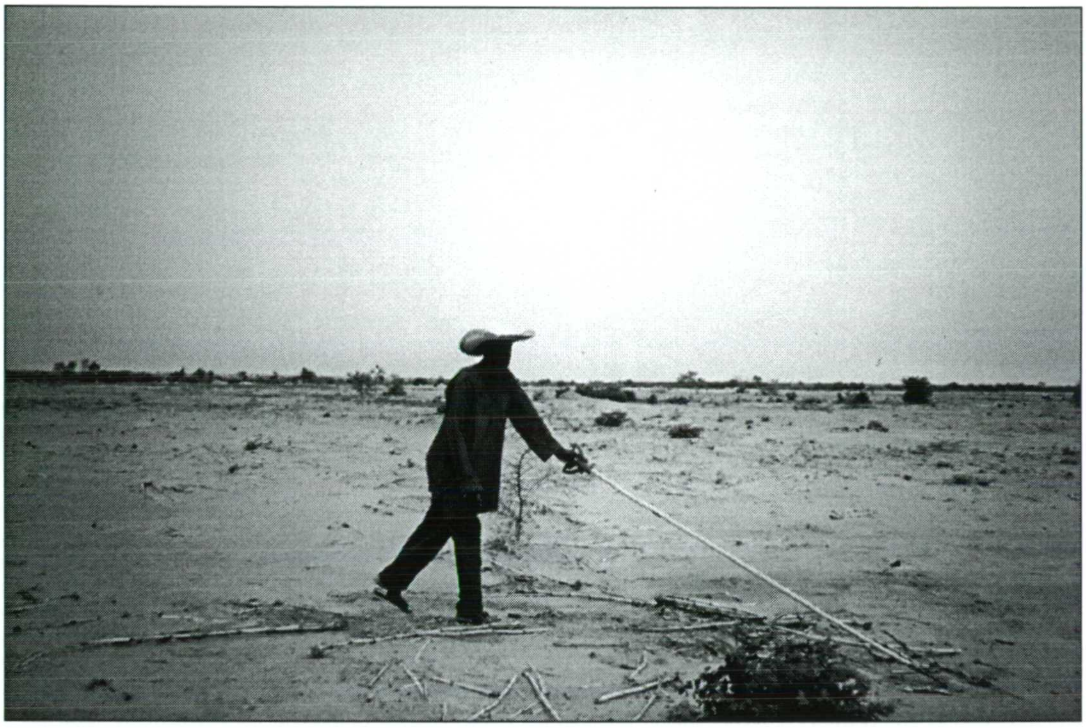
BOX 5.5: RESTRICTIONS TO LIVESTOCK GRAZING ON CROP RESIDUES

Crop residues are an important source of fodder for livestock during the dry season. Farmers graze their animals or invite herders to graze livestock on crop residues after the harvest. While fallow and rangeland can be used throughout the year, the grazing of cultivated land is restricted at certain times of the year. Animals are encouraged to rest or graze on the cultivated portion well into the rainy season as weeds appear, even after the farmers have planted the millet. The farmers observe that animals do little damage to young millet crops, which recover after the animals are removed. However, other crops are not so resilient. Animals that are not watched continuously can destroy cowpea seedlings (usually planted after the third rainfall event), and this causes conflict between farmers and herders. Compensation in the form of a cash payment must be made to aggrieved farmers, depending on the extent of the damage. For this reason, the village chief has decreed that all livestock should be removed from cultivated areas after cowpea has been seeded and grazed only on fallow or rangeland. Livestock are usually moved two days after seeding (usually in the beginning of July) and remain on fallow plots until October. Although this rule prevents most conflicts, farmers plant cowpea at different times (10% of the sampled farmers planted one week after sowing the millet, 30% planted two weeks after and 60% planted after three weeks to a month), and this may lead to confusion and tension between farmers and herders.

Weeding is the second major task in the agricultural labour calendar and although July is considered to be the time of the first weeding, it must begin in the first week of planting if the young seedlings are to be protected from competition for nutrients and water. A critical decision facing every farmer is when to divert labour from late planting on outlying fields to weeding (box 5.6). The size and spatial distribution of the household's fields influence these decisions. Weeding technology consists of a *kumbu* (long-handled hoe) specifically designed to remove the weeds (*subu lalo*) (plate 5.1).

The *kumbu* is also used to thin the millet stands to a maximum of five plants per stand in the early season. Once thinned, the densest stands, which occur on fields close to the village, are those that receive the most manure. In contrast, outlying fields with poor soil have few more than one or maybe two plants per stand. Furthermore, during August the demand for family labour in the second weeding is so high that it is common for fields to be abandoned. Many sampled farmers were not able to pay for supplementary labour for a second weeding. If a farmer suffers a personal misfortune, such as sickness, it can have profound effects on output (through the withdrawal of labour for weeding). It is common in these situations for family and neighbours to exchange their labour so that as many fields as possible are weeded.

Plate 5.1: Amadou Danda-Koy using the long-handled hoe (known in Djerma as kumbu or daba)



BOX 5.6: WHERE AND WHEN TO WEED?

With limited labour, where does a farmer chose to weed first?

Abdou Idé explains how he chooses where to weed:

"I always weed the field that I planted first with millet before I begin to weed the other one. I think it is best to weed as soon as you can after sowing the millet. But is difficult to spend time weeding when you still have to stop to plant. The family gets tired. When the seedlings do start to show I can see how large they are. Then I decide to weed around the largest ones first because these will grow well. If my neighbours and family help I can weed more and tidy the field. I use a hoe to work the weeds into the soil. By July the weeds can be competing with my crops and this is a problem. This is when I must use family to help and weed the strong parts of the fields first, where there is *labu albakante* (good soil). This is also a good time to divide the plants and make sure the strongest plants grow. Where there is plenty of Striga and *hinkini a kangé* plants or the *tassi* is weak and pale then I will leave this area to last".

(In mid-July 1998, Abdou Idé abandoned some of his *tassi* field to the weeds; he chose to work his *gangani* field instead. He felt this field would produce a better crop because the rains were improving).

Plate 5.2: Early-season crop of premature millet

- *Hemar waate*

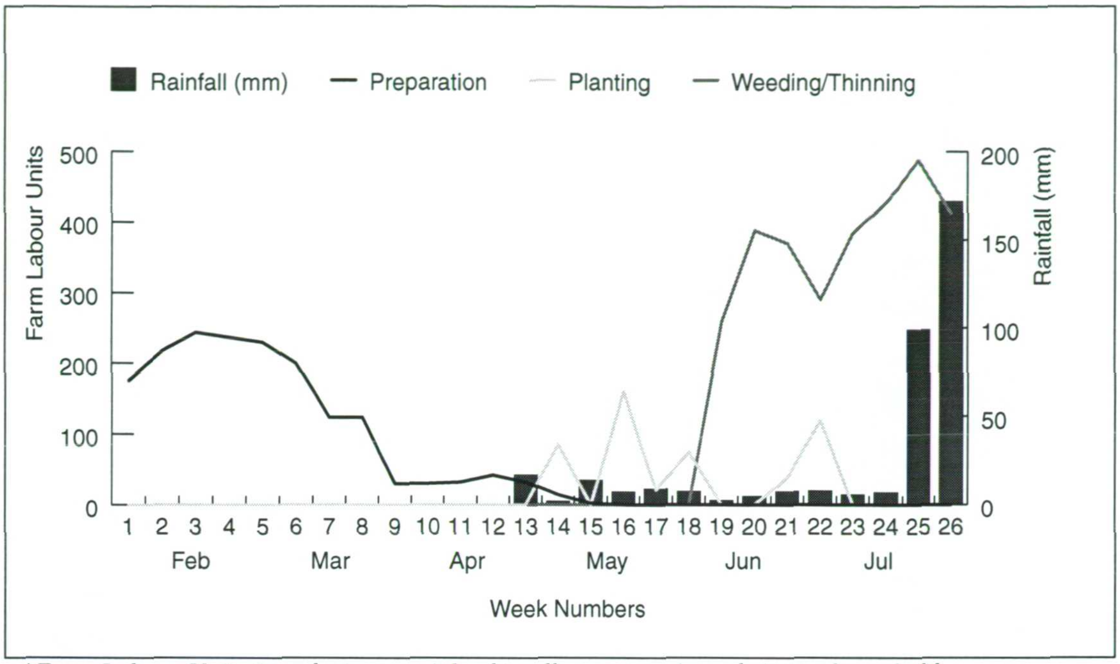
  Time spent weeding the farm is sharply reduced in September and the end of the 'hungry season' comes with the first harvests in which all the family participates. The harvest season is focused on the September millet harvest (*heyni wiyan*). Premature millet grain (plate 5.2) from the short-growing cultivars is often picked before it is strictly ready, to make up for shortfalls in the household food stores. The harvest has many specific tasks including cutting the grain heads, drying, tying the bundles (as a local measure of yield known as 'bottes' in French or *boko* in Djerma). The *boko* of seed heads is transported to storage in *barma* (granaries), which are often built with protective fences to keep out livestock (plate 5.3). The stalks are cut and dried for animal fodder over the dry season. This fodder is stored in bundles in the branches of trees to prevent livestock from eating it too soon.

Cowpea or beans planted early in the season are often harvested at the end of September. After sufficient rainfall, farmers are able to harvest the second millet crop (longer-growing varieties), and the other crops. Harvesting can often last into November. The time of the end of harvest depends on the crop varieties, the size of the farm, the quality of the soil and the rainfall and the amount of labour available to cut and transport the crop to the household compound.

Plate 5.3: A household granary (known in Djerma as barma)

The above sections, describing the agricultural calendar, illustrate the different demands placed on household labour by different tasks at different times of the year. Because the study was interested in understanding land allocation, data collection of household labour management was limited to the key period when farmers were making land use decisions. This period covers the tasks of land preparation, planting and weeding and thinning. The amount of time (converted into weighted farm labour units) that was spent on each of these tasks was recorded to identify patterns of labour investment. Figure 5.2 shows the general trend of labour response to each task and the 1998 rainfall for all households in the study. The graph emphasises the high labour demands for (a) dry season preparation (February, March and April); (b) planting after rainfall events; and (c) weeding and thinning (starting in June).

Figure 5.2: Farm labour usage in sample households and rainfall in 1998 for households 1-20 (source: own data)*



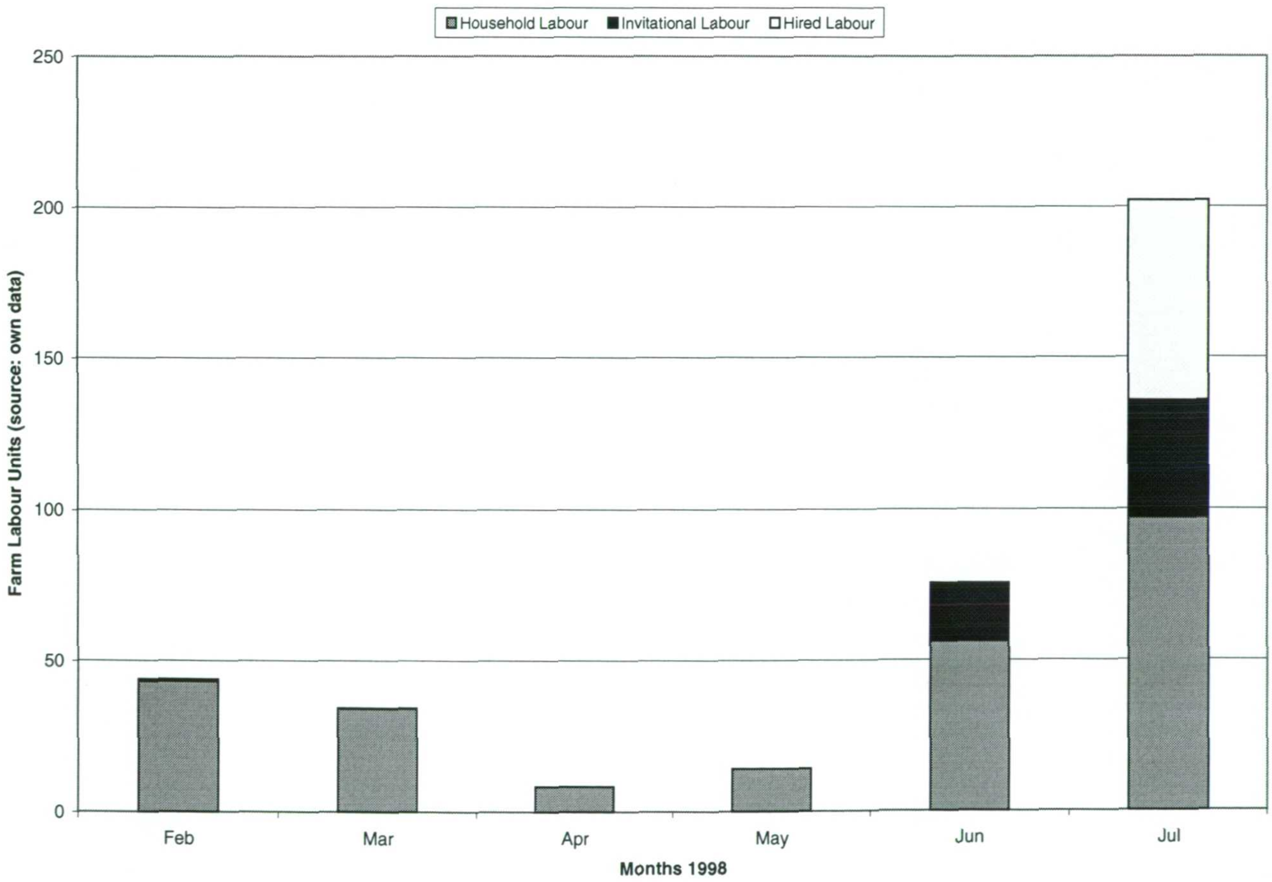
**Farm Labour Units (per day) are weighted to allow comparisons between households: man (13-65 years) = 1; boy (8-12 years) = 0.6; woman (over 13 years) = 0.5; children (3-7 years) = 0.3.*

The graph of labour for planting shows the effect of staggered planting strategies employed for the different crops and of replanting. The graph of labour for the task of weeding shows that there were two periods of peak labour usage for the first weeding activity (until the end of July). The intermediate fall in labour usage for weeding resulted from farmers diverting labour away from this task towards planting in late-June. Weeding could resume after the planting had been completed. The second weeding (in August) was not included in this figure because farmers unanimously felt that the land use change after the first weeding were only the result of labour shortage, pest attack or drought and not from planned decisions.

They also argued that they faced constraints to farm labour in the first weeding (at a time when they claimed to identify which areas of the field would be abandoned if the demands of the second weeding could not be met) but that decisions for land use for each season would be complete by late-July. Patterns of labour usage for individual households are discussed in the case studies at the end of Chapter Six.

The composition of the labour force used in these activities is shown in figure 5.3 and includes 'household' labour, 'invitational' assistance from extended family, friends and neighbours and 'hired' labour. Figure 5.3 identifies a labour shortage during the peak periods of the first weeding which is solved through the use of 'invitational' labour and labour exchanges as well as some hiring. The graph also shows that most households are dependent on family labour. The relationships between labour availability and land use allocation and soil management are discussed in more detail in section 5.3.3 and throughout Chapter Six (see sections 6.2.2.2 and 6.2.3).

Figure 5.3: Composition of household, invitational and hired labour for February to July (total farm labour units for each month of 1998) for households 1-20



5.2 Changes in farmland and soil fertility

Decision-making about farm management through the agricultural calendar is clearly a difficult task and requires farmers to draw on their complex ecological knowledge or *berey* (Djerma for local knowledge). The case study extracts in the previous section have begun to illustrate some of this complexity. This section explores further farmers' narratives of knowledge and perceptions of change in land use and natural capital. As the farmers considered soil fertility change to be the most important natural capital affecting their crop yield, the study focused on soil fertility issues. Throughout the discussion, boxes of the agricultural scientific evidence of land use and soil fertility change are presented.

5.2.1 Changes in farmland

Of the farmers in the study, 90% believed that the area of farmland in the village territory had increased in the last twenty years, while 75% felt that the area of land for grazing animals had decreased. As concerns their individual farms, 80% of the farmers commented that there had been a change in land use during this time; more of their land was now put into short-fallow cultivation for cash crops. 55% of the farmers also said that they had converted bush fields (previously only used for grazing) into long- and short-fallow cultivation in the three seasons. There had been a decrease in the number of trees in the territory in the last twenty years according to 40% of the farmers (the other farmers had not noticed a significant difference). As a result of land use conversion, 45% of farmers claimed they had expanded cultivation into poor quality land closer to the plateau and one farmer was cultivating a field situated outside the village territory close to the edge of the plateau. The remaining 55% of farmers had not expanded into this area due, in part, to land holding location. The land close to the plateau had previously been used only for grazing and for the collection of fuelwood.

Both expansion of farmland and the intensification of the fallow cycle, identified by some farmers, are supported by evidence of from air photographs (box 5.7). Farmers felt that the expansion of farmland was the result of increasing demand and because of increased population, some of it through immigration, but they also believed that crop changes, decreasing rainfall and yield and farm fragmentation were behind land use changes on individual farms. These issues are explored in more detail in section 5.4, and Chapters Six and Seven.

BOX 5.7: SCIENTIFIC EVIDENCE FOR THE EXPANSION OF FARMLAND IN FANDOU BÉRI

Post-harvest air photographs of the study village, taken in 1950 and 1992, were scanned and digitised by Chappell (1995) to show significant changes in land use within the village territory. Although the images cover slightly different areas, only fields within the territory were used in the analysis, which are included in both photographs. The tables below shows that the area of farmland expanded by 42.8%, leaving only 34% of the territory as valley bush or grazing land.

*Land use change within the Fandou Béri territory between 1950 and 1992**

Land Use	Area (km2)		% of Village Territory	
	1950	1992	1950	1992
Bush	73.80	32.90	76.4	34.0
Tiger Bush	4.40	4.00	4.7	4.1
Current Fields	10.90	22.60	11.3	23.4
Recent Fallows	3.95	26.50	4.1	27.4
Old Fallows	3.40	10.60	3.5	10.9
Settlement	0.05	0.06	0.1	0.1
Total	96.56	96.58	100	100

**source: Chappell (1995)*

The conversion of bush to farmland between 1950 and 1992 at Fandou Béri

Land use type as a % of village territory	1950	1992
Bush†	76.4	34.0
Farmland	18.9	61.7
Ratio of conversion (bush : farmland)	4.0	0.6

† *Note that this is valley bush. It does not include the grazing land on the plateau (tiger bush).*

In addition, the air photographs provide evidence of the change in farm management. The table below shows changes in the rotation system. The data indicate a decreasing ratio of old to young fallow, or a shortening in the fallow cycle since the 1950s. There is a corresponding decrease in the ratio of fallow to cultivation. This evidence supports the pattern of intensification indicated by farmers.

Changes in the rotation system between 1950 and 1998 at Fandou Béri

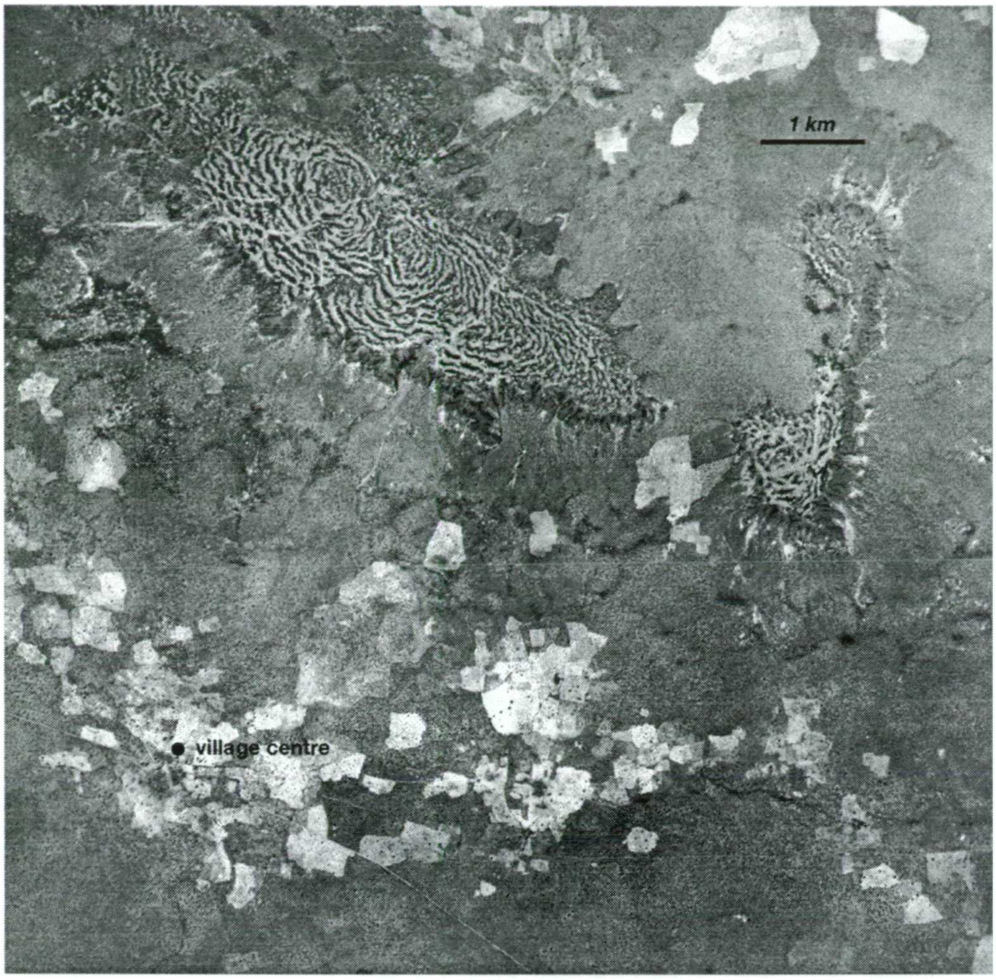
Ratio	1950	1992	1998
Fallow : cultivation	1.5	0.6	0.5
Old fallow‡ (3yrs+) : young fallow	0.9	0.4	0.3

‡ *Note farmers did not consider 'old' fallow to be bushland*

These are trends that are apparent for Niger more generally. The coefficient of fallow/ cultivation (area of fallow land divided by the area of cultivated land) in Niger is said to have dropped from 7.1 to 2.9 from 1960 to 1985; an annual reduction of 3.5% (SEDES, 1987). Reenberg (1996) and Lavigne Delville (1997) have discussed the reduction in fallow, with similar figures, for the Sahel.

The evolution of the landscape is illustrated in the following images.

Fandou Béri in 1950



Fandou Béri in 1992

(source: HAPEX image post-harvest)

5.2.2 Changes in soil fertility

Farmers were asked to assess changes in the soil in Fandou Béri during the last twenty years. It should be made clear that discussion focused on farmers' perceptions of changes within each soil type (see Chapter Four, section 4.6), rather than on soil changes *per se*. According to the farmers, processes of change in soil fertility were related to the transformation of organic matter, the moisture retention capacity of the soils and erosion/weathering and sedimentation processes. They appear to be aware of the processes influencing chemical and physical soil fertility and the influence on soil fertility of organic matter application and the role this plays in enhancing soil humidity (these skills are discussed in 5.3).

Some 80% of the farmers reported declining soil fertility and crop yields on the *tassi* soils. Productivity of the primary cereal crop, millet, has ranged between only 24 and 2715 kg/ha/yr for the last ten years as a result. Farmers believed that the quality of the soil was now more variable and that to maintain yields the fields required increasingly higher inputs (box 5.8).

BOX 5.8: FARMERS' PERCEPTIONS OF SOIL FERTILITY CHANGE

Hamani Salifou farms three small *tassi* fields, with pockets of clay, close to the village. He uses the fields to feed his family of seven. He claimed that the fields have been infertile since his father gave them to him. To maintain soil fertility he once used fallow rotation and manure from his five household goats and sheep but during the 1980s he took part in the extension project. During this time he was able to buy mineral fertilisers cheaply from the project and apply them to his fields. However, with each application of *anasara birji* (white man's manure) he claimed that the land became greedier for inputs. Now that he is unable to buy and use mineral fertiliser, the yields, though still higher than his neighbours, were consistently lower than they were before he took part in the project, despite good rainfall. He claimed that the fertiliser applications had 'killed the soil' and that the fields now demanded increasingly larger areas of fallow each year to restore the fertility. The fallow occasionally receives inputs from passing livestock herds. The area is burned to release nutrients and some manure is transported from household animals kept in the home compound. However, he claimed that the soils are continuing to decline in quality, are becoming paler in colour and that a high level of labour input is now required to weed the ever-increasing quantities of *Striga spp.* and *Mitracarpus scaber*, indicators of poor soil fertility. He maintained that animal manure was the most reliable method of improving the soil quality.

For farmers with sandy-clay *gangani* soils, 30% noted a slight decline in their fertility. Only 10% of farmers said there had been a decline in the soil fertility on the most fertile *botogo* soils. Farmers with *botogo* soils explained that although soil fertility was a lower than in the past, it was still satisfactory and they hoped to maintain yields from these soils without applying inputs. All the farmers believed that the dark fertile areas, known locally as *tombo*, had suffered very little change in soil quality because these soils represented stored fertility from the site of previous human input (such as on a compound or animal pen).

Transformations of organic matter appear to be especially important to the farmers' concept of soil fertility change. Three quarters of them noticed that fields close to the village had become lighter in colour and coarser in texture in recent years, indicating a decrease in organic matter. There were differences in their perceptions of the organic matter content of the *botogo* soils, with one third of the farmers considering there to have been some decline, while the rest claimed that there had been no change. Their perceptions about the capacity of *botogo* to retain moisture also varied. Of the farmers interviewed, only 10% had observed a decline in the *botogo* soils' capacity to retain moisture whilst half said that they had not noticed any difference. About 35% of farmers thought that the moisture-retention capacity of the *tassi* soils had declined, due to losses of organic matter, whereas 80% thought that this decline was the result of the amount of rain falling in a given season. Given the high rainfall variability of the area and the close relationship between rainfall and the release of soil nutrients in *tassi* soils, this seems an astute assessment. Only a few farmers considered that rainfall had not changed at all. Soil moisture was seen to transform available nutrients producing a dynamic pattern of change in potential soil fertility. Since farmers made a strong connection between rainfall and soil fertility, it was only reasonable that following a series of poor rain years they would have opinions of declining soil quality for crops.

While cultivating, farmers referred to changing soil fertility in the predominately *tassi* valley soils. The changes were seen in one location and were not a spatially assumed soil development by farmers. The process was reflected in the naming of the stages of the rotation system. Farmers described how land progressed from fertile cleared *sacara* in the first year of cultivation to *lalibanda* the year after, *kwar* *kwari* (white sand with less organic matter) in the third season and finally to *boulouga* (degraded land) after five years. After cropping for five years, farmers observed that some of the field will need to be rested in fallow (*farezenon*), nutrients added or, if particularly degraded, abandoned to long-term bush until the farmer has the ability to add enough inputs. Under *farezenon* farmers noticed changes in soil colour and texture and the development of *korobanda* crusting. These developments are discussed further in section 5.2.2.1 (Indicators of soil fertility change). It is clear that there are many correspondences between local explanations of soil fertility change and those of orthodox science (for example, role of water in the decomposition of organic matter and release of nutrients, the positive effect of organic matter on soil structure and soil moisture, and that manure and organic matter are vital sources of nutrients).

However, most farmers expressed concern that the use of organic inputs had not yet managed to achieve yields that corresponded to the bumper harvests when they could obtain subsidised inorganic fertiliser (see section 5.3.1 on inorganic fertilisers). Three quarters of the farmers noted the contribution that NPK mineral fertiliser had once made to their crop yields and the quality of their soil when they could afford them up to the early 1990s. In contrast to the beliefs of the Djerma, the Fulani groups reported no such declines in soil fertility on their fields, which they attributed to the constantly high inputs from their livestock.

Soil erosion was judged to be on the increase at both territory and field level according to 60% of the farmers. This corresponds to the results of scientific research in the village, which found high rates of erosion on some fields (box 5.9). However, there are many contradictions in the way that farmers talk about erosion. Some of this may be due to confusion over the term, where short-term damage by water or wind erosion to crops is easy to see and understood to be 'erosion', whereas long-term removal of soil is not seen as such. Many farmers stated that people were reluctant to observe the rules introduced by local authorities or the government regarding deforestation and soil conservation. Furthermore, many openly confessed that they were repeating information about the negative impacts of long-term erosion that had been told to them by rural extension workers in 1993. The farmers felt that it was difficult to judge what the impact of soil erosion had been on the soil fertility of their fields, especially since it is a long-term process and not always visible. They noted that the rocky patches (*tondu kakasia*), found in fields beyond the stony laterite plateau (*tondu bon*), had not increased in size. A decrease in water erosion was even suggested by some farmers who believed that the amount of rain falling on their fields was less than had fallen on their fathers' fields.

BOX 5.9: SCIENTIFIC EVIDENCE OF SOIL EROSION AND PERCEPTIONS OF SOIL CHANGE IN FANDOU BÉRI

Soil erosion is widespread phenomenon, especially in the early rainy season (May-July) when wind-blown sand and wash may severely damage young crops (Michels *et al.*, 1995a), it is said that the soil productivity of these soils declines when fertile topsoil is continually removed by wind (Mainguet and Chemin, 1991; Sterk *et al.*, 1996). While wash causes short-term and small-scale gully erosion, wind erosion is almost certainly a more serious cause of soil loss. In Niger, Sterk *et al.* (1996) showed that there was a significant loss of nutrients in wind-eroded material from agricultural fields. While erosion of total element (TE) content (of K, C, N, and P) increased with height from topsoil, vertical profiles of TE mass fluxes showed that the main mass of nutrients was transported just above the soil surface by saltation, which is a short-range transport process. Saltation redistributes soil over short-distances; it can be trapped by grasses, while suspended material is transported over larger distances and results in a loss of nutrients. Michels (1994) found that wind erosion during the three-month Harmattan season did not exceed the erosion that took place during one storm event in the rainy season. There can also be little doubt that organic matter and essential nutrients are removed preferentially by wind erosion (Leys and McTainsh, 1994). Organic matter and nutrients are preferentially bonded to finer particles, and these are both more susceptible to erosion, and more likely to removed far from the point of erosion, and thus lost to the local agro-ecosystem. Probably more important, organic matter both helps to prevent erosion by forming wind-stable aggregates (Tisdall and Oades, 1982), and itself acts as a store for nutrients (in soils that have few enough other stores, and where short-term storage capacity is probably very important). As fines are lost, the topsoil becomes coarser, and so has less capacity to hold nutrients and water.

The scientific evidence in Fandou Béri can be used to suggest that there are high rates of erosion judged by global rates (Warren *et al.*, 2001). Soil loss measured using the 137-Caesium method (see Chappell, 1995; 1998), for a thirty-year period, produced a rate of wind and water erosion of 40 t ha^{-1} yr^{-1}. Water erosion occurred on the edge of the plateau and locally in fields, while sandy soils suffered from wind erosion.

Wind erosion can be counteracted by technical control measures (Buerkert *et al.*, 1996; Baidu-Forson and Napier, 1998). Particle transport is reduced by mulching the soil surface (Michels *et al.*, 1995b; Buerkert *et al.*, 1996; Sterk and Spann, 1997; Buerkert and Lamers, 1999), by planting wind breaks (Renard and Vandenbeld, 1990; Mohammed *et al.*, 1995; Michels *et al.*, 1998), or by tillage and ridging (Klaij and Hoomoed, 1981; Bielders *et al.*, 2000). Only recently has research on soil erosion in Niger included farmers' opinions of erosion processes and soil change (Taylor-Powell *et al.*, 1991b; Lamers and Feil; 1995; Krogh, 1995b; Rinaudo, 1996; Neef *et al.*, 1996; Sterk and Haigis, 1998). Sterk and Haigis (1998) found that 63% of their sample of farmers considered wind-blown particle transport to be damaging to their cropping systems and described patterns of erosion at different scales; 92% of their sample farmers employed techniques to reduce erosion. Lamers and Feil (1995) found that 48% of their sample of farmers considered parts of their farms to be susceptible to erosion. They described the eroded patches (*gorous*) as crusted (*gangani*) and often growing in size to become a degraded area (*tanka*). Taylor-Powell *et al.* (1991b) noted how the loose sand was blown from micro-lows to micro-highs. Their detailed survey classified the micro-lows as eroded surfaces caused by sheet erosion, leading to exposed Bt horizon after the removal of the A horizon. Neef *et al.* (1996) studied the influence of land rights on the adoption of erosion control measures in SW Niger and found that customary tenure did not allow non-owners to plant trees on borrowed land. Trees are often seen to compete with crops (Sterk and Haigis, 1998).

In terms of soil fertility change, most scientific studies view the effect of erosion to be the decline in the mineral component. They see this to be the main issue, unlike the farmers who view the loss of organic matter to be the most important process (Breman, 1998). However, scientific studies do show that organic matter is an important source for nitrogen, phosphorus and improved cation-exchange capacity (CEC), and that this influences the availability of potassium, calcium and magnesium. In addition, Hoogmoed (1999) noted its ability to improve structural conditions and water retention.

Nevertheless, all the farmers could describe the common processes in erosion, weathering and sedimentation and over different timeframes. They described how the gullies from the plateau moved gravel and stones onto fields in the valley, sheet-wash moved topsoil on the cultivated fields and vegetation caught fertile soil and built ridges. The farmers described how the wind carried loose sandy material from higher areas, exposing the fertile, but 'hard' *gangani* soils, and depositing this loose material in the valley bottom, building up the sandy *tassi.* Most thought that short-range processes of soil erosion and soil transfer were on the increase in fields of all soil types because of the decreasing area of bushland and the shorter fallow periods. The violent winds, that proceed the early rains, were also blamed for the loss of topsoil. Some 95% of the farmers claimed to have observed changes in soil quality as a result of increasing lengths in cultivation periods. However, 60% of the farmers noted that these same winds brought new topsoils and nutrients. In general, many did not have the negative perception of erosion that is common among agronomists, claiming that it was a process that contributed to soil development and spatial micro-diversity (an essential part of their management strategy).

While discussing 'in soil' changes, older farmers would frequently provide nostalgic images of the quality of the soil and the productivity of the family farm in the past, a common problem when asking about the past (box 5.10). The nostalgia problem raises the possibility of there being subjective bias in the information about the past given by the older farmers. This form of narrative may also reflect the farmers' experiences of aid and research in the region. Projects in the past have relied on external assistance in the form of inorganic fertilisers to counter patchy evidence and widespread perceptions of declining soil fertility. Yet, crop yields have not declined significantly over the last 20 years for example (see Chapter Four). The influence of intervention is discussed further in Chapter Seven. Unfortunately, without nutrient balance analyses or long-term data on soil fertility or crop yields at Fandou Béri it is difficult to establish whether or not there has been a decline in soil quality.

BOX 5.10: PERCEPTIONS OF SOIL FERTILITY CHANGE AS RELATED BY TWO ELDERLY FARMERS

Djibo Abdoullaye lives on the edge of the village with his two wives and children. Much of the farm work is left to his two youngest sons because he feels that it is too hard for an old man. His eldest son farms a plot of land in the village given to him by his father and he and his new family have remained in the village. Djibo Abdoullaye has always lived in the village, inheriting the farm and his farming skills from his father. He recounted the 'old days' when so much land was available, crop yields were high and there were more trees. He recalled larger tracts of bushland for grazing animals. Farm management revolved around shifting cultivation when he was young, with more extensive burning of the bush. Inorganic fertilisers were not needed for good crop yields, even on *tassi* soils, if there was sufficient rain. He had observed a change in the quality of these soils. The good dark soils on his field near the village had become lighter in colour in the last thirty years. This field used to produce all the crops his family needed, but millet and cowpea yields had decreased and the soil no longer supported all the crops he would have liked to grow. To grow cash crops of sorghum, hibiscus and groundnut he must use plots of better quality soil further away. He has to rely on organic inputs from his family smallstock, but has only three small goats and lacks transporting equipment. The animals are rarely corralled on the fields because his son does not want to spend time on the field with them; instead fodder is taken to compound. He claimed that he knew his soils were 'sick' because bushes grew slowly, weeds had increased (*Mitracarpus scaber* and *Striga spp.*) and plants that indicated good soils no longer grew on the farm (*Diheteropogon hagerupii* and *Digitaria gayana*). He admitted that these changes might also be due to changes in rainfall and that 'strong' (fertile) soils remained around trees. His son reported crusting on the cultivated *tassi* soils, which was not a problem when he worked them. Djibo Abdoullaye feared for his sons' future in farming this 'tired' land, without sufficient inputs, and believed that farming would be harder work. He was concerned that leaving less of the farm in rest, in order to sustain crop yields, meant that more soil would be prone to erosion.

Oumarou Hassane lives with his wife and extended family outside the village. He relinquished control of the farm when he felt he had become too old and ill to carry out the farm labour, although he still maintained a family field immediately next to the compound. The family farm had been divided between his sons and their households. According to Oumarou Hassane, the land cover and quality of the soil on his farm had changed considerably in his lifetime. He believed that his family was only able to maintain current yields by corralling the household cattle and smallstock on the fields. He claimed that his field received enough manure and household waste, which created 'strong' black soils, to allow continuous cultivation. However, neighbouring fields, particularly *tassi* fields around the village, were 'tired'. He remembered a time when cash crops, such as cotton and groundnuts, were supported by these soils. Although he acknowledged other reasons for the decline, he wondered if in the future the soils would be able to support cash cropping if soil fertility was not maintained. He claimed to have observed increases in weed species on cultivated fields, decreasing productivity and fewer trees. He showed photographs that he claimed were of these local trees over twenty years ago. The bushland, which he recalled as once surrounding much of the farm, is now entirely cultivated or in short-fallow.

The simplistic nostalgic narrative of decline given by the elders masks a more complex narrative of farmers' perceptions of soil management and soil fertility. The diversity in individual household circumstances and knowledge, evident in the rest of this chapter, makes it clear that descriptions of both soil fertility management and of trends in soil quality are more complex. Furthermore, the farmers' perceptions of fertility were based around an interaction between soil characteristics and climatic factors, and these produce a distinctive pattern of soil fertility that scientific soil tests are often unable to discern (Osbahr and Allan, submitted). These perceptions include a dependency on *tassi* soils during low rainfall years. However, intrinsic soil characteristics are only part of the farmers' perceptions of fertility. The relationship between farmers' perceptions of fertility and scientifically measurable characteristics is often complex because ethnopedological knowledge incorporates social and cultural, as well as environmental considerations, and it is the combination of these factors that dictates perceptions of the productivity of the land. These issues are discussed further in the next section and in Chapter Six (section 6.2.4.1).

5.2.2.1 Indicators of soil fertility change

To understand the quality of the soil, the farmers used a variety of indicators and from this information were able to tell when fertility had changed and to what extent. Discussion in this section is limited to the primary indicators they used: soil characteristics; plant species and associations; and crop growth characteristics. Farmers considered this local knowledge to be 'common knowledge'; learned through farming experience. The idea that common and local knowledge can affect individual choices and priorities for resource use is analysed further in section 5.4.

All the farmers in the study claimed to use changes in the organic matter content of soils (through colour, texture and moisture, and the level of crusting) as a guide to soil quality. Three quarters of the farmers referred to a lighter colour and coarser texture when suggesting that the *tassi* soils around the village were decreasing in quality. Changes in these characteristics would indicate a decrease in organic matter. Dark colours appearing around bushes and trees, for example, indicated to them that the soil fertility was improving. The farmers observed that there were fewer areas of black sandy soil (*tassi biri*), which indicated a higher organic matter content, and more red and white sandy soil (*tassi kirey* and *tassi kware*), which had a lower organic matter content than in years gone by. In addition, the farmers cited extreme cases where the *tassi* had become so poor that it was renamed *boulougu*.

The type and extent of surface soil crusting as an indicator of fertility was referred to by 75% of the farmers. These farmers noted that fallow areas over three years old developed a dark patchy crust, known locally as *korobanda* ('frog's back'). They claimed that this crust indicated an increase in soil fertility. Scientific analyses in the village by Piper (1998) confirmed the fertile characteristics of this algal crust. The crust is lost after cultivation, illustrating the microscale ephemerality in soil fertility status. In addition to *korobanda*, crusting was observed on *tassi* and *gangani* soil. However, according a quarter of the farmers, these crusts or hard pans, unlike *korobanda*, were indicators of declining soil fertility after prolonged cultivation and made the soil harder to work. These farmers claimed that *tassi* areas that were underlain with *botogo* were those most at risk of hard pan, unless the field had received high organic inputs. The farmers who farmed this type of soil believed that if the hard pan was controlled, the soil was productive. However, given the farmers' limited ability to work intensively, hard pan areas were often not cultivated.

All the farmers used crop characteristics as indicators of soil quality. The quantity of millet grain harvested was commonly used as an indicator. The relationship between yield and soil fertility became more pronounced during bad rainfall years according to the farmers, and was seen directly to be related to soil moisture. Some 65% of the farmers used the quality of specific crop characteristics, such as the size the plant, yellowing in the leaves, blackening of the roots and the size of the seed head, to help them to decide when the soil fertility was declining.

Likewise, characteristics of non-cultivated vegetation was used by the farmers to indicate soil fertility. The presence or absence of plant species, in particular non-cultivated grasses, and their associations were also used by over 80% of the farmers. *Mitracarpus scaber* (known locally as *hinkini à kange*), *Eragrostis tremula* (*kullum*) and *Striga spp.* (*striga*) were used to indicate soil fertility decline on all soils. On *tassi* and *gangani* soils the farmers used *Cenchrus biflorus* (*dâni*), *Diheteropogon hagerupii* (*haramdam*) and *Digitaria gayana* (*gaji*) to indicate soil fertility improvement, while on *botogo* soils *Zornia glochidiata* (*marbku*) and *Cenchrus elegans* (*bâta*) were used to indicate improvement.

The Fulani farmers in the study were more knowledgeable about plant associations than the Djerma. Knowledge of fodder grasses and the quality of grazing pasture were a reflection perhaps of their traditional role as livestock carers. In contrast, the Djerma, traditionally cultivators, offered a more comprehensive knowledge of soil changes and soil management. Both the Fulani and the Djerma farmers were reticent about discussing knowledge outside their traditional domain in the company of the other. Both groups publicly proclaimed admiration for the knowledge of the other and much was made of people's traditional skills. Since both groups displayed considerable knowledge about all sections of their natural environment in subsequent private discussion, their public reluctance to discuss knowledge belonging to another ethnic group may suggest a display of cultural identity. Any public projection of the identity of the other may damage the state of co-dependence and social relationships between the groups. Despite the recent history of conflict between herders and farmers in the region (Turner, 1999a/b), the two groups currently have a symbiotic relationship, whereby the settling Fulani can offer manure exchange, care of and advice on livestock management and the Djerma can offer land and farming experience.

This local knowledge is used in everyday farm management, as shown in the following section.

5.3 Using local knowledge to manage soil fertility

The farmers in Fandou Béri used their local knowledge to exploit the natural environmental diversity of their farms. To do this successfully, the farmers used their practical experience, observation, information and ideas from other farmers, depending on the indicators described in section 5.2.2.1 to improve soil structure, raise nutrient status and thereby increase crop yield. To work with environmental microdiversity and to manage these dynamic resources, their perspective of soil fertility management incorporated the ephemerality of soil status, the historical dynamics of soil fertility and the need that soil fertility practice should reflect natural flexibility. This reading of the environment is counter to many understandings in conventional agricultural science.

This section deals essentially with the soil fertility knowledge and management practices themselves rather than the farmers' knowledge, entitlement and knowledge transfer, which are discussed in section 5.4. The management of soil nutrients is especially important because they are the most influential 'natural capital' resource that influence crop yields, and which the farmers are able to control.

The farmers in the study used a variety of practices to manage soil fertility (table 5.1), some of which have been practised for generations. These included the use of crop residues, crop rotation, fallowing and the application of leaf litter, soil from termitaria, compost, manure and ash. The farmers chose the methods according to the amount of material available, labour requirements and the availability of land.

Table 5.1: Soil fertility practices used in 1998 (source: own survey)

Soil Fertility Practice	1998 % Farmers n = 20	% Fields n = 58	% Tassi* n = 41	% Gangani* n = 8	% Botogo* n = 9
Fallow: **a) short (1-3 yrs)** **b) long (4 yrs+)**	85 80 30	48 38 10	60 50 10	13 13 0	30 0 30
Inputs from Livestock: **a) corralling or grazing** **b) manure transported from homestead**	80 55 65	34 19 24	38 25 30	13 0 13	30 10 30
Mineral fertilisers	0	0	0	0	0
Nitrogen-fixing crops	100	72	85	38	40
Ash from burning	40	19	23	0	20
Protecting trees	80	69	75	50	80
Laying of millet stalks	100	100	100	100	100
Recycling and composting organic materials	90	84	90	70	52

* Although the local soil type is variable within all fields, values are given for the primary soil type found in the field.

Table 5.1 shows that 85% of the farmers remained dependent on fallow rotation for soil fertility improvement. Most of this fallow was in a short-rotation of less than three years and most was on the *tassi* fields. Most cereal-legume intercropping was practised on these *tassi* fields. There was little fallow on the *gangani* soils. Most long-term fallow was practised on the *botogo* soils, a reflection of the extra labour input required to work these fields, which are predominately outfields. Although 80% of the farmers used inputs from livestock to increase soil quality, only 19% of the fields received inputs from corralled animals and most of these were the *tassi* fields around the village. Only 24% of the fields received manure transported from penned animals at the homestead. Table 5.1 indicates that the farmers fertilised their *tassi* and *botogo* soils with transported manure to the same degree. It is clear that without inorganic fertiliser applications, the farmers were obliged to invest labour in organic treatments (such as recycling, laying bushes and crop residues). The higher investments were consistently on the low quality *tassi* soils around the village, where labour costs were low.

The households can be categorised by the labour intensity required by the soil fertility practices they chose to use (table 5.2). For example, fallow or grazing of livestock has low labour costs, while transporting manure, composting and crop residue management requires high labour costs. Of the survey households, half were using methods of soil fertility improvement that had a low labour cost, while only 21% used more intensive measures. This suggests that the farmers' soil fertility practices were constrained by expense and labour, or they were making alternative choices for investment. The relationship between the level of investment and households' resource endowment is analysed in Chapter Six.

Table 5.2: Categorisation of households according to labour intensity of soil fertility management practice

Number of Households	Category 1 Intensive use	Category 2 Moderate use	Category 3 Limited use
20	21 %	29 %	50 %

(source: own survey)

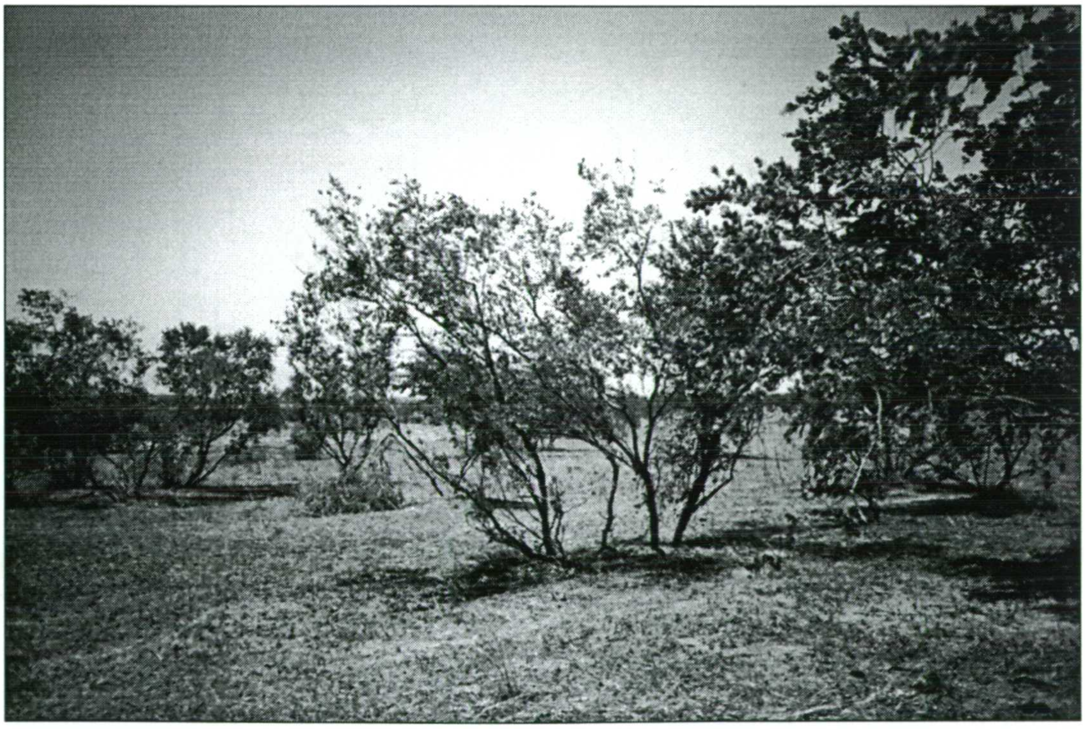
The remainder of this section discusses in more detail the role of the various practices observed during this study and the farmers' perceptions of their role in nutrient management. Each practice corresponds to a part of the nutrient cycle (section 2.2.4). Therefore, the practices have been arranged according to their roles in adding nutrients to the farm and maximising the recycling of nutrients already within the farm, limiting the losses of nutrients from the farm and increasing the efficiency of nutrient uptake.

5.3.1 Inputs and nutrient cycling

Fallowing

Section 5.2.1 identified a pattern of expansion in the land in cultivation, as fallows have shortened to less than 3 years over the last part of the 20th century, with a corresponding decrease in the area of farmland in long-term fallow. Although the farmers felt that long-term fallows were beneficial to poor soil, they claimed that there was only enough land available to rest part of the farm. Some believed that their fathers had been able to leave whole fields in fallow for up to 15 years. Many fields around the village were now in permanent cultivation or had only a small part in fallow. In spite of these trends, farmers in the study identified fallow rotation to be one of the most defining practices to their soil fertility management and also that it had been historically important to their farm management. They observed that the fallow period was vital for the accumulation of nutrients and the maintenance of crop yields when other sources of nutrient input were so limited. Farmers defined fallow as a rest period in the crop-rotation system during which natural vegetation was allowed to re-establish. All the farmers had areas of their farm in fallow (plate 5.4), although not all felt that they were dependent on fallow rotation as the primary means of soil improvement. Other reasons for fallowing land are discussed in Chapter Six (section 6.2.2 and 6.2.3).

Plate 5.4: Four-year old fallow on tassi soil near the village



The farmers distinguished two benefits of fallow for adding inputs to their soil. Firstly, there was the ability of the bushes and grasses on the fallow to catch dust brought in the Harmattan winds and the early season dust storms. They also believed that the fallow vegetation caught topsoil blown or washed from nearby fields (discussed in section 5.3.2). The farmers observed that dark soil built up in mounds or ridges around the bushes and grasses in fallow. Secondly, the farmers attributed the better fertility and darker colour of this soil, to the addition of leaf litter and decay of roots. They noted that different species determined the degree of soil enrichment, the rate of leaf litter and the change in soil colour. The most common shrub, *Guiera senegalensis,* was described as an important source of fertility and they noted that crops flourished when planted in the soils around coppiced bushes of this species. The farmers maintained that coppicing of bushes allowed the vegetation to regenerate quickly and also provided fertile soil for planting crops each season. The farmers observed a relationship between the extent of these benefits, the growth of the fallow grasses and bushes and the quality of the rainfall.

In addition to fallow, the farmers told of the importance to them of preserving selected trees in their fields. They observed that the trees maintained fertile niches as did the bushes and grasses, and described a process of nutrient replacement from the leaf litter decay, which can then be used by the crops. The protection and maintenance of *Faidherbia albida* was recognised by the sample farmers as a method of improving soil fertility. These trees shed their leaves during the rainy season, allowing crops to be planted immediately around them. Despite the felling or pollarding of many trees for fuel and fodder, solitary selected trees are a common feature in West African fields because they provide shade or useful products. Their shade and fodder attract livestock, which contribute to the nutrients that are already provided by leaf litter and organic activity, by depositing dung under the trees. In Fandou Béri, trees are also considered important in marking boundaries between fields.

The farmers' perceptions of the benefits of fallow vegetation and trees for soil fertility are supported by numerous scientific studies (box 5.11).

BOX 5.11: THE SCIENCE OF FALLOWING

Fallow rotation systems have traditionally been one of the most important management practices in agro-ecosystems in West Africa (Raynaut, 1997) and the formation and benefits of the 'islands of fertility' around fallow plants has also been a focus for research (Wezel, 2000).

It is well known that trees reduce wind velocity (Geiger and Manu, 1993; Michels 1994, Kainkwa and Stigter 1994), especially in a field where they have very dense foliage as a result of repeated cutting. The reduced wind velocity leads to a deposition of soil and dust in the vicinity of the vegetation, creating nutrient-rich microtopographic mounds under shrubs (Buerkert *et al.*, 1996; Chappell, 1998; Bielders *et al.*, 1998). Many studies have also focused on the role of vegetation cover in reducing erosion (see Buerkert *et al.* (1996) on the practice of grass maintenance, particularly *andropogon*, to limit water wash). Sterk and Haigis (1998) concluded that the maintenance of selected bushes on otherwise unprotected fields that had been prepared for cultivation, was a reliable practice that prevented the loss of topsoil during early season storms (also see Léonard and Rajot, 1997).

In addition, material originating from the Sahara (mostly from the Bodelé depression) is transported in the Harmattan winds of the dry season and is trapped by vegetation and washed into the soil with the first rains (Drees *et al.*, 1993; Herrmann, 1996). The material is an important source of phosphorus (as P_2O_5) and potassium (as K_2O) (Hermann *et al.*, 1996). Harris (1999) found this material to account for 20% of phosphorus inputs in soils in Sahelian Nigeria, and as much as 60% for large farms (0.67kg/ha), while it was a source for up to 95% of potassium inputs (15kg K/ha).

Nutrients that are leached from the subsoil may be recaptured by maintaining trees in the cultivated area, as the decomposition of fallen leaves makes the 'lost' nutrients available again to plants. The leguminous tree, *Faidherbia albida*, which drops its leaves during the rainy season, is the most efficient (Vandenbeldt and Williams, 1992; Payne *et al.*, 1998). The plants also have an important role for nutrient recycling, creating the 'islands of fertility'. The leaf litter builds up a ring of organic material around the plant, enhanced by bioactivity. The better crop growth in these 'islands of fertility' produces a thick straw mulch of crop residue. This improvement in biomass relative to other parts of the fields further enhances the soil fertility (Buerkert *et al.*, 1996). However, Wezel (1998) found that changes in carbon and nitrogen near bushes and trees were only significant after long-term fallowing of at least 15 years. Exchangeable ions, such as Ca_2^+ and Al_3^+, phosphorus and pH were found to be more favourable in soils after fallow than after cultivation (Wezel, 1998). Wezel *et al.* (2000) argued that the optimal conditions in fallow occurred when there were 450 shrubs per ha. Furthermore, fallow age effects soil fertility and the vegetation community (Abudakar, 1996; Osbahr, 1997), as the following table by Wezel and Boecker (1998) illustrates:

Soil parameters of fallow in SW Niger on sandy soils for different age classes

	Age Classes				**Anova**
	1-5	**6-10**	**11-15**	**>15**	
0-10 cm	**N = 71**	**N = 31**	**N = 2**	**N = 33**	***p***
C (%)	0.189 ±0.076	0.229 ±0.109	0.252 ±0.169	0.337 ±0.128	<0.001
N (ppm)	151 ±67	185 ±91	201 ±100	313 ±151	<0.001
pH	5.6 ±0.3	5.6 ±0.3	5.7 ±0.6	5.7 ±0.3	0.53
Sand (%)	91.0 ±3.6	92.0 ±2.8	88.6 ±2.5	91.0 ±2.5	0.28
Silt (%)	5.6 ±2.7	4.4 ±1.8	7.2 ±2.6	5.7 ±3.3	0.06
Clay (%)	3.4 ±1.3	3.5 ±1.5	4.2 ±0.1	3.3 ±1.0	0.71

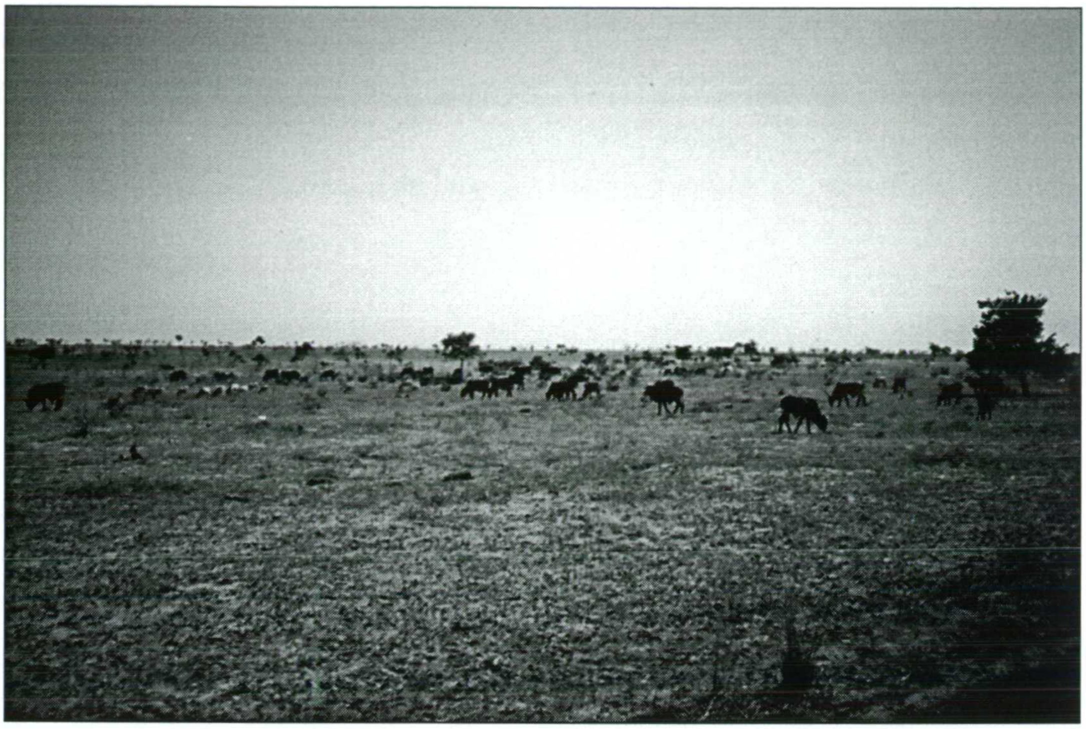
On sandy soils, organic matter is important in nutrient fixation and species differentiation. While the clay and silt content also contributes to species differentiation, Wezel and Boecker (1998) found only heavy grazing and drought brings about dramatic changes to species composition. Wezel *et al.* (2000) argued that even short-fallow provided significant soil fertility benefits. They found that nutrient enrichment ratios were highest in young regenerating fallow and that the rate of soil transport and additional nutrient accumulation slowed as plants became established. Only the most limiting nutrient, phosphorus, was increased under long-fallow (Bationo *et al.*, 1998). These studies highlight the complex implications of changing fallow practice; although fallow vegetation is an important mechanism for nutrient improvement, changes to the rotation system may not be as detrimental to soil fertility levels as first thought, especially if additional sources of inputs are found or recycling mechanisms are improved.

Inflows of nutrients from livestock (grazing, corralling, transported manure)

There are several sources of inputs of nutrients associated with livestock: manure exchange with Fulani, grazing herds, corralled animals, manure transported from the compound and from the village's refuse heaps. There are differences in the livestock composition between Djerma and Fulani households (refer to table 4.4), providing opportunities for co-operation.

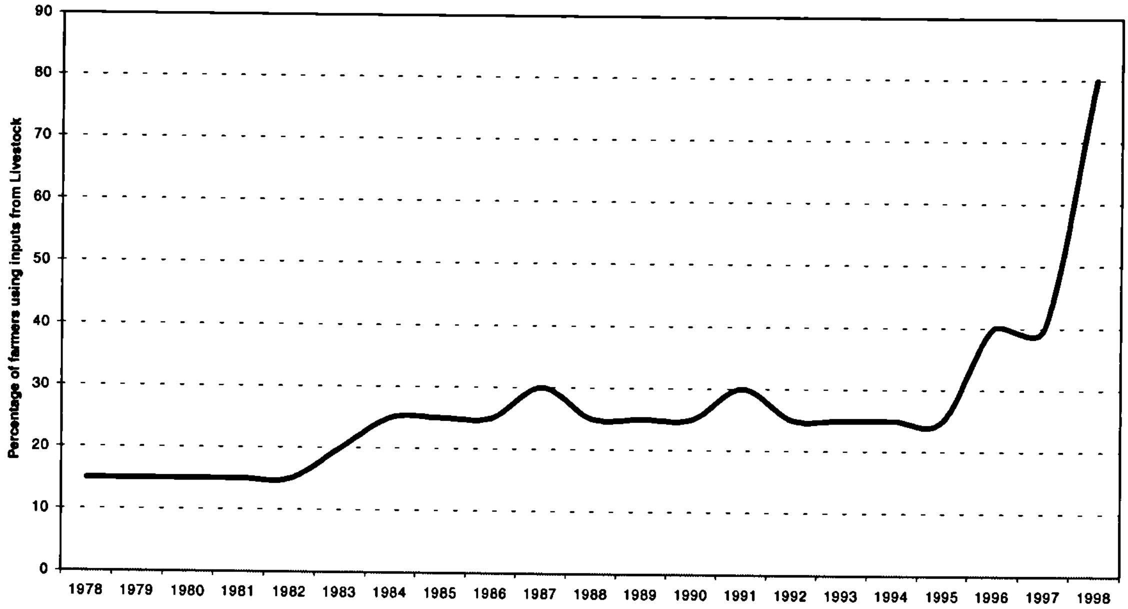
Inputs from grazing animals, usually on fallow parts of the farm, demanded little labour investment and therefore the farmers believed grazing from passing herds to be a 'gift' (see box 5.1). Smallholders with fallow land on cattle routes to the local water sources regularly received this kind of input. In addition, 40% of farmers had entered into an exchange contract with Fulani during the last 3 years, whereby the animals were grazed on fallow, or crop residues at the end of the season, in return for the inputs (plate 5.5). Many exchanges required payment in cash or food to the herders. If local Fulani cared for Djerma cattle, an exchange contract was still considered necessary to access the manure. The Fulani farmers were able to maintain high inputs from livestock throughout the year. The Djerma said that they preferred the cattle to graze the *tassi* fields because they believed cattle did not damage the soil in a way that was evident on *botogo* soil. Several farmers also believed that cattle prevented surface crusting on the *tassi*. However, the farmers thought that the quality of the dung deteriorated as it lay on the soil surface over the dry season, but they rarely found enough time to work the manure into the soil.

Plate 5.5: Fulani livestock grazing Djerma fallow to the west of Fandou Béri



The farmers in the study felt that the expense and limitations to the exchange system had encouraged them to seek investments in smallstock when possible. The exchange system between Fulani and Djerma may not have fully recovered after the loss of herds in the droughts of the 1970s and 1980s. The Djerma argued that the ownership of smallstock allowed them to corrall animals when and where they wanted, without dependency on exchange arrangements. All the farmers felt that ownership of livestock was an indicator of wealth and security. The more successful or socially important Djerma households owned large herds, although they did not approach the size of herds owned by the Fulani. These Djerma farmers often chose to entrust some to local Fulani, who kept the cattle or small ruminants in their family herd. There had been a recovery in the numbers of livestock, mostly of small ruminants, since the droughts in the 1970s and 1980s. As a result, the number of farmers using organic fertiliser derived from livestock had doubled since the mid-1990s (figure 5.4). The most dramatic increases, in the 1990s, followed the cessation of inorganic fertiliser subsidies and a period of high yields (refer to figures 4.1 and 5.5). The farmers claimed that manuring from livestock was less expensive than the use of inorganic fertiliser and that its effects on soil improvement lasted for several seasons.

*Figure 5.4: Growth in number of Djerma farmers in study with access to manure from livestock in Fandou Béri between 1978 and 1998 (weighted by numbers of informants, thus controlled for changing sample size) **



** 1978-1996 data from the SERIDA Project/1997-1998 data from own fieldwork (n = 20)*

Even though there had been a significant increase in livestock ownership in recent years, the amount of manure applied by corralling was still relatively small in relation to the total cultivated area. Only 25% on average of each farm was manured using corralled livestock and most of this was on cultivated *tassi* soils around the village (table 5.3). Inputs to *botogo* fallows came primarily from grazing. The table also shows that households who used few of these inputs were adding the highest inputs from livestock to their short-fallow *tassi* fields (up to 52% of the farm).

Table 5.3: Percentage of fields manured on sample farms (source: own data)

Category of intensive soil fertility practices (see table 5.2)	**Number of fields** (n = 58)	**% of total cultivated fields manured**	**% of *tassi* fields manured** (n = 41)	**% of *gangani* fields manured** (n = 8)	**% of *botogo* fields manured** (n = 9)	**% of fallow fields manured** (n = 29)
1	12	52	53	0	40	33
2	17	19	17	20	23	14
3	29	4	3	7	4	11
Average	-	25	25	9	22	19

All the farmers agreed that corralling was most efficient on *tassi* soils around the village, because the short distance required little labour investment and because these soils were perceived to have the lowest quality. The farmers explained that their smallstock were kept in the household compound but often 'hobbled' on crop residues after the harvest. The best time to corrall livestock on the area destined to be cultivated was, according to the farmers, just before the rains. The farmers explained that the animals transferred nutrients from the fallow. Since there was enough fallow and grazing land for animals relative to cultivated fodder, there was probably a net import of nutrients from fallow to field. The animals would also be corralled on low quality *tassi* fallow during some evenings throughout the year, but especially during the rainy season when crops were grown on the cultivated areas and stored fodder would be running out. Some 75% of the farmers perceived smallstock to be better for improving *botogo* soils than cattle because they caused less compaction of the soil surface.

Of the fields receiving inputs from livestock, 24% were benefiting from inputs of transported manure from tethered animals at the homestead. These animals were kept for sale, but provided easily accessible manure. All the farmers targeted the applications to poor quality soil. Intensively managed fields received the largest applications of manure, with applications focused on the *tassi* fields around the village. Cultivated fields far from the village received less transported manure, although the fallow areas were grazed, because this practice requires high investments of labour and transport equipment. Farmers without livestock were dependent on grazing arrangements, passing herds or on gifts of manure from family members. Those farmers with sufficient labour and transport sent their children to collect dung from the rangelands or from the communal refuse heaps outside the village. Before the first rains, the composting manure was then transported using donkeys or carts to the nutrient-poor fields.

Rising livestock ownership and an increase in the numbers of smallstock kept in household compounds creates extra demands on grazing space and access to fodder. The farmers believed that the only constraint to increasing livestock numbers was the finance needed to purchase them. However, if the number of draft animals (donkeys) were also to increase, farmers would have to ensure that sufficient supplies of fodder could be brought in from the fields. Currently donkeys are mainly owned by Fulani and the wealthier Djerma households. Box 5.12 shows that the farmers' perceptions of the benefits of inputs derived from livestock are supported by scientific studies.

BOX 5.12: THE SCIENCE OF LIVESTOCK INPUTS

Several studies have been undertaken in the region on the benefits of livestock inputs and targeted applications (Powell, 1986; Casenave and Valentin, 1989; Schlecht, 1995; Bouma *et al.*, 1995; 1996; Powell *et al.*, 1996; Rockstrom and de Rouw, 1997; Brouwer and Powell, 1998; Defoer *et al.*, 1998; Ramisch, 1998; Harris, 1999; Hiernaux *et al.*, 1999; Ikpe *et al.*, 1999) as the tables below illustrate:

Effect of overnight manuring on soil properties (source: Powell, 1986)

	Unmanured areas (n = 8)	Manured areas (n = 8)
pH (%)	5.1	5.8
Organic carbon (%)	1.50	1.91
Total N (%)	0.131	0.164
Available P (ppm; Bray-1)	4.6	9.6
CEC (meq/100g)	4.34	6.15

Effect of manure on soil surface chemical properties in West Africa (samples taken at first crop harvest after manure application)

Manure Application	pH	Organic matter (%)	Total nitrogen (mg/kg)	Available phosphorus (mg/kg)	Source
5	5.37 (4.98)*	0.39 (0.29)	202 (153)	10.3 (5.3)	Bationo and Mokwunye (1991)
20	6.21 (4.98)	0.58 (0.29)	285 (153)	22.9 (5.3)	Bationo and Mokwunye (1991)
Not recorded	5.8 (5.1)	0.33 (0.26)	164 (131)	9.6 (4.6)	Powell (1986)
3.6	6.51 (6.18)	0.18 (0.15)	Not recorded (4.3)	5.7	Powell (unpublished)
2.1	5.04** (4.86)	0.31 (0.28)	Not recorded	Not recorded	Powell (unpublished)
3.1	5.45 (5.20)	0.31 (0.28)	150 (138)	11.0 (6.1)	Smith *et al.* (1997)

* Values in parenthesis are soil properties in unmanured plots.
** pH in KCl, otherwise pH in water.

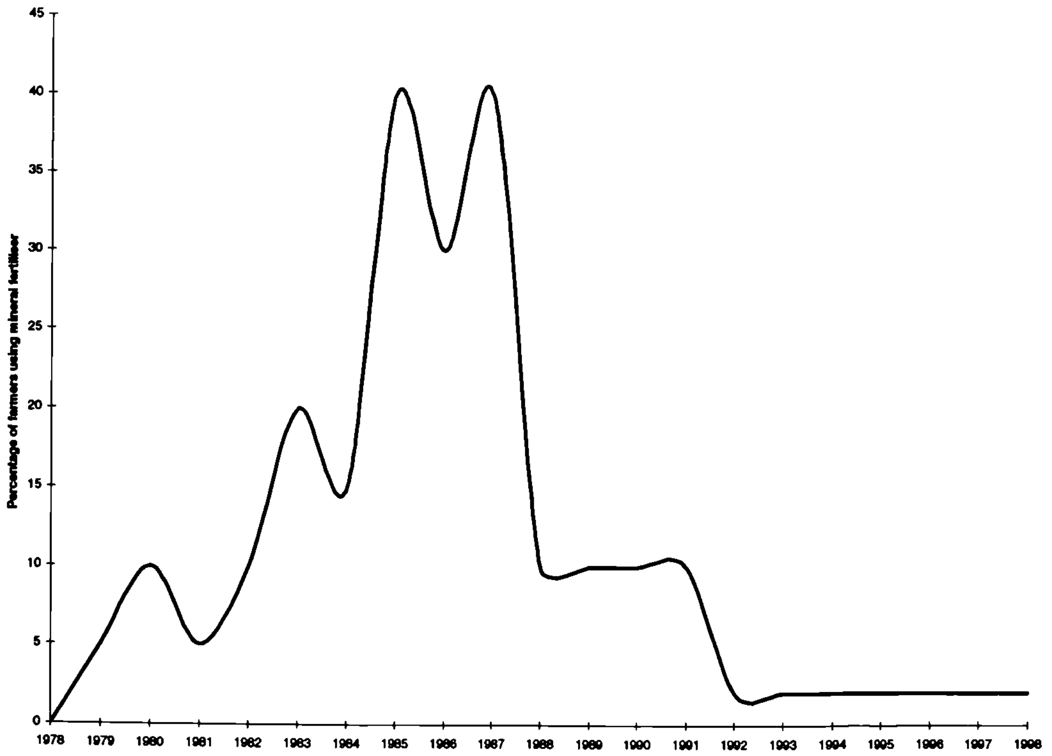
Research in Niger by Schlecht (1995) and Ayantunde (1998) supported farmers' perceptions on the timing of manuring, while Gandah *et al.* (2000) and Esse *et al.* (2001) found supporting evidence for 'precision inputs'. Ayantunde *et al.* (2000) also investigated the benefits of night-corralling. They found that manuring at the beginning of the rainy season improved fertility because the livestock feed on richer vegetation at this time and the manure is in a semi-liquid form that facilitates its mixing with the soil during the first weeding. Brouwer and Powell (1998) found that inputs from livestock improved soil structure and moisture retention and that livestock urine improved soil fertility for up to ten years. A study by Harris (1999), in Nigeria, highlighted the importance of manure as a source of nitrogen, phosphorus and potassium. Rockstrom and De Rouw (1997), working in the nearby village of Banizoumbou, confirmed farmers' perceptions of targeted applications. They found that farmers who applied manure on the lower parts of the field (*botogo soils*) were able to increase yield more significantly than those who applied manure upslope. However, upslope applications were able to increase the infiltrability on crusted zones. Bouma *et al.* (1995; 1996) found the relative wetness of the soil (amount of infiltration) to be important in determining the reasons why upslope plots improved in nutrient content after corralling but found heavily leached plots to be have losses. Hiernaux *et al.* (1999) investigated the effects of livestock grazing on the physical and chemical properties of *tassi* soils in this region. A reduction in crusting, an improvement in soil structure and a lower soil pH was observed following grazing. The study also observed compaction due to trampling in the topsoil under bushes but only under very intense grazing pressure, confirming the farmers' perception that cattle did not damage the *tassi* soils. Casenave and Valentin (1989) found that grazing cattle on *botogo* soils could have a negative effect as a result of compaction and that farmers perceived differences in the impact of grazing on different soil types. Research by Brouwer *et al.* (1993) added the observation that slope shape (e.g. concave, convex) had a significant effect on the effectiveness of cattle or sheep manure. They concluded that sheep were more effective than cattle in improving the soil fertility on most slope types.

The inputs need to be made at certain times of the season, and 'parking' cattle on a field a long time before the rains, such as in a crop-residue exchange with Fulani livestock, is not necessarily an effective means of nutrient improvement in the short-term (Schlecht, 1995; Powell, 1986). This is because animal manure does not deliver nutrients in forms that are as readily available as those found in fertiliser, Harmattan dust or the nitrogen supplied by leguminous crops (Harris, 1999). Manure contains complex biochemical compounds that require time to breakdown. Therefore, not all nutrients that are applied as manure will be available to the crop in the first growing season. Some compounds, such as the lignins and tannins in humus, may break down very slowly in the soil, whereas the metal oxides in Harmattan dust and the nutrients in organic fertiliser are readily available to plants. For this reason Harris (1999) argued that any nutrient balance based on livestock inputs must be seen in terms of the complexities of nutrient cycling processes. Research by Hiernaux *et al.* (1997) in SW Niger focused on these nutrient transfers, concluding that livestock recycled 50% of organic matter, 48% of N and 85% of P intake and that fields with corralled animals received 5 to 13 times more manure than average village land (at stocking densities similar to those at Fandou Béri). Schlecht *et al.* (1997) highlighted the benefits of precision input applications from cattle, sheep and goats, providing advice on how to exploit livestock herds for better manuring of cropland.

The use of mineral fertilisers and rock phosphates

The farmers considered applications of inorganic fertilisers too expensive, especially after structural adjustment policies in the 1980s ended the government's involvement in the delivery of fertiliser, as well as in extension projects and credit facilities in the village (see Chapter Four). Figure 5.5 shows the sharp drop in the use of mineral fertilisers by farmers in the study since the late-1980s. However, using inorganic fertilisers remained a popular concept with the farmers. They maintained that mineral fertilisers and rock phosphates were easy to transport, had guaranteed quality, and when used in targeted application, such as in each planting pocket, were beneficial to yield. They noted that applications had to be adjusted according to how the rainy season developed, otherwise crops might be 'burned'. Farmers had to buy mineral fertilisers for cash, which is difficult for most, and often the fertiliser was sold in larger quantities than they could afford.

*Figure 5.5: The use of mineral fertiliser for farmers in the study between 1978 and 1998**



Source: 1978-1996 data from the SERIDA Project/1997-1998 data from own fieldwork (n = 20)

**N.B. The peak in use is associated with a fertiliser research project – see Chapter Four*

The inability to find large sums of cash at a time when household incomes were low meant the farmers believed that they had to diversify into organic alternatives, replacing rock phosphate with ash and mineral fertilisers with manure. They considered that inorganic fertilisers were best used in combination with organic inputs, especially on fields where livestock had been corralled or on low quality *tassi* soils. Although a small-scale business for inorganic fertiliser distribution was established in the area in 1999, at the time of the study the farmers rarely had access to mineral fertilisers or rock phosphates. The farmers claimed they would only be able to obtain small quantities and therefore the applications would be at a fraction of the recommended rate. They felt that investment in inorganic fertilisers would only be possible if there were credit facilitates and the profitability of a crop was high, but they acknowledged that it would remain a risky investment given the likelihood of rainfall failure.

BOX 5.13: THE SCIENCE OF INORGANIC FERTILISERS

A number of research projects have examined the benefits of mineral fertilisers and rock phosphates in the region (Bationo *et al.*, 1992; 1993; Sanchez *et al.*, 1997) Under the right conditions inorganic fertilisers can significantly increase soil fertility and crop yields (Bationo and Mokwunye, 1991; Powell *et al.*, 1999). Research by INRAN (Institut National de Recherches Agronomiques du Niger) and ICRISAT (International Crop Research Institute for Semi-Arid Tropics) has shown that average grain yields over 1000 kg ha^{-1} can be achieved when recommended rates of fertiliser are applied (22.5 kg ha^{-1} of P_2O_5 and 46 kg ha^{-1} of N). Harris (1999) concluded that one bag of inorganic fertiliser could provide inputs of nitrogen more or less equal to the input from fallow and nitrogen fixation in one year. Breman and Sissoko (2000) believe that inorganic fertiliser applications are the only practical solution where soil fertility is very low, especially if they are used in combination with organic methods.

Cultivation of nitrogen-fixing crops

According to the farmers in the study, growing cereals in association with legumes, particularly cowpea, had been practised for generations. Table 5.4 shows that this was still a common practice. The farmers claimed that cowpea was becoming a more important crop because its market price had increased and the crop residue provided a source of fodder for livestock. All the farmers believed that leguminous plants were beneficial to soil fertility. These perceptions have been confirmed by research (box 5.14). Cowpea intercrop with millet was grown on 72% of the sample fields, often around the edges of fields (table 5.4).

Table 5.4: Average cropping pattern in 1998 (source: own data)

Cropping Enterprise	**% Tassi** (n = 41)	**% Gangani** (n = 8)	**% Botogo** (n = 9)	**% Farmers** (n = 20)	**% Fields on farm** (n = 58)
Millet	100	100	100	100	100
Cowpea	85	38	40	100	72
Sorghum	8	38	80	55	24
Hibiscus	30	50	20	70	24
Peanut	0	13	50	25	10
Sesame	10	25	50	45	19

Table 5.4 also shows that 85% of cowpea intercropping was found on *tassi* soils, the more demanding cash crops were grown on *gangani* and *botogo* soils. In addition to the main farm production, women cultivated small plots within fallow areas for cash crops including cowpea. When taken again into 'full' cultivation, the farmers considered these gardens to have higher levels of nitrogen.

BOX 5.14: THE SCIENCE OF LEGUMINOUS CROP ROTATION

Dakora and Keya (1997) and Rao *et al.* (1995) showed the benefits of intercropping a variety of legume crops, especially cowpea (*Vigna unguiculata*) with groundnut and millet, and Becker and Johnson (1999) showed the benefits of legume fallows in intensified systems. However, experiments by Bationo and Ntare (2000) in south-west Niger found a fallow-millet rotation to supply more mineral nitrogen than a legume-millet rotation under continuous cultivation and that nutrient losses as a result of the removal of millet residues sometimes outweighed the N-fixation. This suggests that while legumes can be important sources of nitrogen, they are not as beneficial as long-fallow rotation, Harmattan dust inputs or composted inputs from livestock. Harris (1999) found N-fixation to contribute 2.5 kg/ha of nitrogen to cropped farmland and, although an important source for farmers with low inputs, legumes often supplied only 40% of farm nitrogen inputs.

Ash from burning

Farmers told of the benefits to soil fertility of the burning of organic material and the incorporation of ash into the soil. Scientific research has supported this knowledge (box 5.15). However, the farmers in the study believed that burning was a less effective practice than when their fathers had been farming. They thought that there were fewer areas of long-term fallow with large bushes and established perennial grasses on their farms and therefore, there was less vegetation to burn. With less vegetation to burn and less ash, they felt that fewer nutrients would be replaced in the soil. To compensate for these changes, the farmers cut branches from bushes on older fallow to burn on the cultivated area of the field. The 40% of farmers who regularly burned their farm thought that burning needed to be practised with care because burning upslope areas would mean that the rains could wash the ash and the nutrients away. They also felt that this practice gave them more control over targeting low fertility areas of the field. Only *tassi* and *botogo* soils were burned. The cuttings from *gangani* soils were transported to other soils for burning. Cutting of large bushes at the edge of cultivated plots also minimised pest attack to crops (which are attracted to bush cover) and, according to the farmers, this is another and equally important reason for burning.

5.15 THE SCIENCE OF BURNING

Masse *et al.* (1997) investigated the effects of different bush-fire management on the soil quality of short fallows. They found that the most significant improvements to organic matter on sandy soils were made during early burning. Brouwer and Powell (1997) warned that local soils around Fandou Béri are vulnerable to leaching. Burning large areas may increase leaching, causing carbon, nitrogen and sulphur losses (Allen, 1985). Masse *et al.* (1997) found loamy soils to be most at risk from erosion and degradation during early and late burning. Additionally, burning grasses does not eliminate the roots and intensive hoeing is still needed to prepare the soil. Reducing the fallow period produces less biomass, and thus less ash after burning. Additional fertilisation may be provided by cutting branches from surrounding bushes and applying these to the plots prior to burning. This is known as the 'chitimene' technique (Pingali *et al.* 1987). Burning cut branches in small piles or the stumps of bushes during land preparation after a fallow, reduces soil acidity and leads to local concentrations of phosphorus, calcium, magnesium, potassium and even nitrogen under 'slow burning' conditions (Orr, 1995; Juo and Manu, 1996; Buerkert and Hiernaux, 1998).

Recycling and composting organic materials other than manure

The farmers described how the harvest of grain, stalks, beans, fuelwood and pasture for fodder or grazing accounted for nutrient losses on their fields. The location of nutrients within the harvested biomass affects whether the nutrients will be recycled within the farming system or exported from it. The farmers knew that if they removed the products from the fields then they were lost from the farm and, therefore, recycling of waste products was considered to be one process whereby some of the nutrients could be conserved. This was particularly important to those farmers who had small numbers of livestock.

All the farmers in the study reported that they were investing more labour in these organic treatments than a decade ago because of the limited supply of inorganic fertilisers. In addition to manure inputs, the main methods of incorporating organic matter into the soil were: digging in of weeds during July and August; cutting and laying of cereal stalks on the surface to decompose and attract termites (see box 5.16 and 5.17, and plate 5.6); and the composting of prunings, leaf litter, crop residues and household waste. The waste from processed crops (plate 5.7) was also taken to the field to rot. Many farmers described compost heaps on their close fields. This material was distributed during field preparation. 'Green manures' were used by 90% of the farmers in the study and all the farmers practised mulching. 'Green manures' were targeted to low fertility *tassi* soils, although some of the farmers also targeted areas of *gangani* and *botogo*.

However, the farmers felt that making compost was a very labour-intensive process and was not as popular as the use of livestock. They argued that composting would be more popular if there were labour-saving methods for producing and transporting the material. 10% of the farmers believed that the recycled crop residues had limited nutrient content and little impact on the soil fertility. These farmers were convinced that the incorporation of crop residues into the soil was only beneficial to soil fertility if cattle or small ruminants also grazed the field, leaving manure. They claimed that this reduced the labour demand for working the crop residues into the soil during preparation as the animals had already achieved this task while grazing. If farmers had serious labour constraints, they claimed that they might consider burning the crop residues. The farmers considered the incorporation of weeds into the soil with a hoe during the growing season to be most important in raising the level of organic matter and the water-holding capacity for the developing crops. However, some farmers felt that the volume of biomass and variable rains limited the benefits of recycling weeds.

BOX 5.16: SCIENTIFIC REPORTS ON GREEN MANURES AND MULCHING

Mabrouk *et al.* (1997) defined two variants of mulching in their work in Niger: 'paillage' and 'branchage'. Marschner *et al.* (1995), Lamers and Feil (1995), Wezel and Böcker (1999) and Buerkert *et al.* (2000) examined the practice of 'paillage' by farmers (laying of millet stalks) in experiments in south-west Niger. These studies found significant benefits to soil fertility, reduced erosion, crusting and increased termite activity, as did Mando and Stroonsnijder (1999). Several studies have investigated the protection these practices provide from erosion (Buerkert *et al.*, 1996; Leonard and Rajot, 1997; Sterk and Haigis, 1998; Buerkert and Lamers, 1999; Bielders *et al.*, 2000). Wezel and Böcker (1999) demonstrated that 'branchage', the laying of cut *Guiera senegalensis* branches (the most common shrub), could increase crop yields by 68-94% and estimated that a 1,000 kg/ha application would produce maximum yields. Sterk and Strossnijder (1997) estimated that a 1,000kg/ha application reduced total mass transport rates by wind by 42.2% during the early rains. These applications are best made as spot applications (Lamers and Bruentrup, 1997; 1999) but the quantity advised is above what most farmers could achieve. Dakora and Keya (1997) reviewed the benefits of mulching and 'green manures', such as incorporating weeds, crop residues and household waste into the soil and found that sustainable food production was linked to the recycling of plants by farmers.

Plate 5.6: Mulching with millet stalks

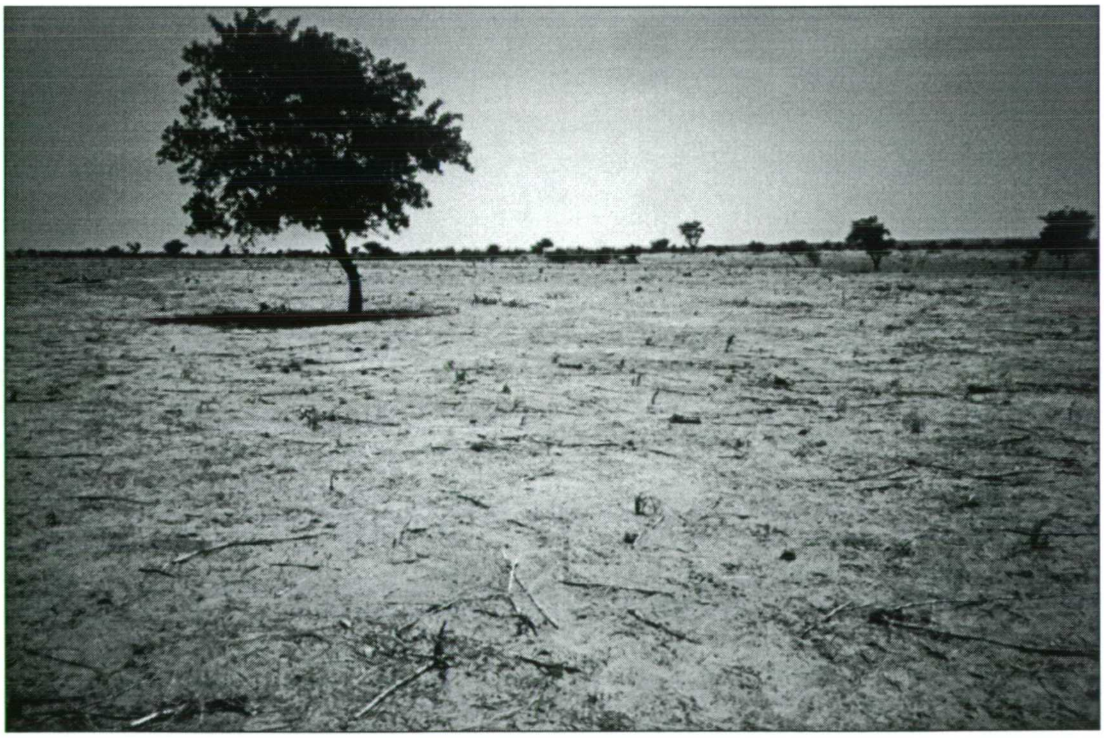


Plate 5.7: Pounding millet grain produces waste chaff used in composting

Encouraging termites

All the farmers in the study considered that the encouragement of termites increased soil fertility. The farmers observed that termites consumed the material laid during 'paillage' and 'branchage' and the resulting bioactivity improved the soil structure and led to the break up of hard surface crusts (see box 5.17 for scientific research).

5.17 THE SCIENCE OF TERMITARIA

Several studies have shown the activity of termites (predominately *Macrotermes falciger*) to contribute to the micro-scale modification of soil properties in the region (Watson, 1976; Kang, 1977; West *et al.*, 1984; Geiger *et al.*, 1992; Manu *et al.*, 1996). Recent studies have shown that termites incorporate organic matter into the soil, improve infiltration and increase fertility (Geiger *et al.*, 1993; Manu *et al.*, 1996; Mando *et al.*, 1996; Léonard and Rajot, 1997). Differential decomposition of crop residue by the termites creates islands of improved fertility within fields. This is because termites preferentially select finer-soil fractions for the construction of their mounds, encouraging aggregate formation and the cementation of soil particles into massive secondary structures that are extremely resistant to erosion. Termites have been found to lower the bulk-density of soils leading to increased water-holding capacity. Watson (1976) and West *et al.* (1984) observed higher soil pH in termite mounds compared to surrounding soils, resulting from the accumulation of calcium carbonate. Kang (1977) noted an increase in exchangeable bases and available P, and a decrease in exchangeable aluminium levels relative to surrounding soils. The abandonment and erosion of termite mounds results in spatial microvariations in the texture and chemical properties of the surface soil. Rotmans (1994) estimated that crop growth is improved by 20% on soils of former termite mounds. However, higher fertility may lead to excessive early crop growth, which could be a disadvantage if water is lacking later in the season (Brouwers and Bouma, 1997).

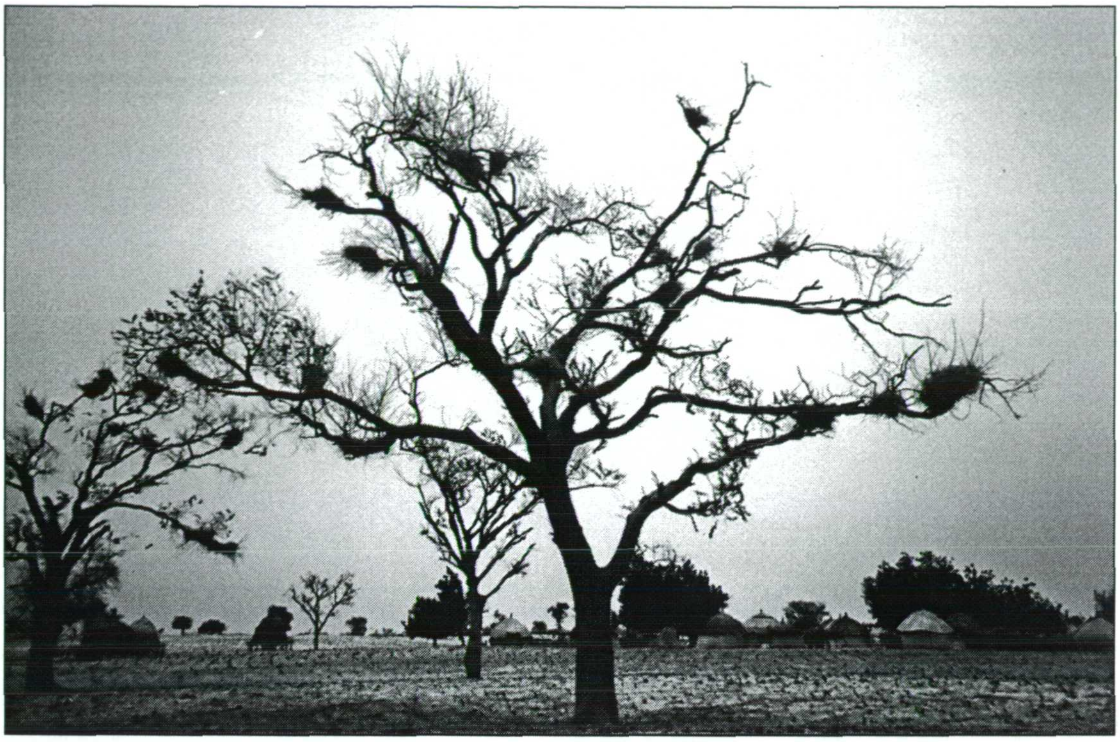
5.3.2 Measures to minimise nutrient losses (runoff, erosion and leaching)

Maintaining vegetation cover to control erosion

Every farmer in the study considered the maintenance of vegetation cover in the territory as a whole, or on a part of their farm, to be their primary means of protecting the soil from wind and water erosion. Scientific studies support this opinion (box 5.11). The farmers believed that vegetation cover was best at slowing short-term erosion and the transport of material. They thought that the transport of topsoil was unlikely in fallow areas on the farm because of protection the vegetation cover offered. However, 45% thought that the protection was reduced in fallow areas if heavy grazing had taken place at the end of the dry season.

Some 75% of the farmers considered it essential to maintain a limited vegetation cover on the cultivated part of their fields, in the form of uncut bushes, at the beginning of the rainy season and at the time of the first storms. As most of the farmers were unable to mobilise enough labour to uproot and burn these bushes once the planting season had begun, they coppiced the bushes instead, which requires little time or labour. They did not consider this practice to be a constraint to production because coppicing allowed the bushes to produce new shoots if the area was abandoned due to poor rainfall, limited labour for planting or weeding. The area could thus be quickly restored to fallow, and provide soil protection and fodder. The farmers explained that if cleared areas were planted, the new shoots of the bushes would not grow fast enough to compete with the young crops. However, trees in the cultivated zone that farmers considered to be of low value were pruned because they believed that millet could not grow in shade and that the branches attracted nesting birds that ate new seed (plate 5.8).

Plate 5.8: Pruned trees with birds' nests on the fields around the village



Vegetation cover was also maintained at the edge of fields. Grasses, bushes and trees were maintained around fields to trap topsoil and prevent the nutrients from leaving the field by wind or water erosion. The farmers observed that the trapped topsoil created low ridges, which distinguished field boundaries and prevented disagreements between neighbours. They claimed that the practice of planting additional grass plants on young fallow to prevent soil erosion, as shown to them by intervention work in the village, was too labour-intensive and was therefore not practised even where serious gully erosion occurred. The farmers had observed serious run-off and water wash on fields in the north of the territory but were unconvinced that the high labour investment involved in controlling these would yield high returns. They felt that crop residues were less labour intensive (e.g. cutting millet stalks in February), protecting soils from and early season storms and used for animal grazing. See box 5.16 for scientific research on using millet stalks.

5.3.3 Using spatial variability to increase the efficiency of nutrient uptake

Perceptions of spatial variability were an integral part of the farmers' decisions about soil fertility management. They considered the high spatial variability in soil characteristics to play an important role in the marked disparities of crop growth and establishment and that these variations were more pronounced because production conditions were not very favourable and their farms only received low inputs.

The farmers believed that the causes of soil variability were complex. Both farmers and scientists attribute it to termite activity, small differences in nutrient availability, soil texture, land use history, microtopography, bush-trapped eolian dust, local crust formation, seasonal water-logging, stoniness and the nitrogen-fixing abilities of specific species (box 5.18). However, unlike the scientific research, the farmers in the study considered the spatial variability of their soils to be dynamic and their local knowledge classifications reflected this ephemeral status (see section 4.6 and 6.2.4.1). Farmers' understandings of spatial variation were linked to qualities of the soil, such as texture, colour and structure and also to its geographical and topographical relationships. They believed that soil varied most where there had been human activity, especially around the homesteads and where animals had been corralled.

The specific local knowledge that the farmers had about micro-environments, the history of land use, and indicators of soil fertility allowed them to target management, decide on planting strategies and levels of investment, and to be able to match their crops to the perceived nutrient status. They matched differences in the nutrient requirements and the tolerances of stress of different species with the range of soil fertility levels in their fields. In addition to the type of crop chosen, the type of cultivars of the cereal crops were chosen to match the soil fertility. For example, sorghum was preferentially planted on the *botogo* soils, and millet and cowpea on the *tassi* soils (table 5.4). Crop sequencing and rotation was also important as the fertility changed over time, and from place to place. The farmers believed that their choice of cultivar was response to the rainfall, soil moisture and nutrients, interactions with other crops in the mixture, market price, the crop's resistance to pests and diseases, labour supply, as well as to taste, colour and cooking properties. They believed in maintaining the diversity of their genetic base because it provided them with more choice in selection and adaptation. Modified short-maturing cultivars, introduced by intervention projects, were still used. 'Red millet' was most commonly used, taking 90-120 days to maturity from planting. Other local varieties have longer growing periods but were resilient to drought. Box 5.4 has already shown that the sample farmers intercropped complementary crops, that had different niche requirements, to maximise nutrient-use efficiency and these rotations were based on soil fertility indicators.

In addition to using micro-variability, the Djerma who were questioned exploited the opportunities afforded by the coexistence of hard and sandy soils by farming at least one field of each. Those farmers who owned fields with different soil types claimed to consider variations at the farm-level when choosing a planting strategy. Some 75% of the farmers in the study had two to three fields of different soil type. Some of the farmers did not vary planting density over the field but they did vary the density between different fields, incorporating opinions on the level of erosion and soil fertility. The farmers believed that larger-scale variability in soil quality helped them to spread the risk of crop failure as a result of rainfall variability. Sequential planting would take place on *tassi* soils first, because their productivity depended on sufficient rainfall. They also believed that sufficient rainfall allowed them to plant any soil type and that ownership of a diversity of soil type supported a greater diversity of crops.

The farmers also used their experience of spatial variability to target nutrient applications. Through this knowledge, they were able to make nutrient applications on specific soil areas, around a plant or planting hole, and at timely points in the growing cycle. The farmers believed a flexible approach to applications meant they were able to adjust mixtures of manure and other organic fertilisers as they became available.

5.18 THE SCIENCE OF SPATIAL VARIATION

Scientific research in Niger has partially explained why some farming practices are particularly effective and it also confirms the indigenous knowledge of soil variations (Bernhard-Reversat, 1982; Pieri, 1989; Breman and Kessler, 1995; Brouwer and Bouma, 1997). Human agency in the creation of micro-variations has been observed. Buerkert and Stern (1995) identified the importance of old livestock pens, homestead sites, and sites of past cultivation in creating niches of soil fertility. Brouwer *et al.* (1992) observed the role of termite activity (Mando *et al.*, 1996) and livestock inputs, while Drees *et al.* (1993) observed the importance of dust from the Harmattan winds, and Piper

(1998) and Geiger *et al.* (1992) examined the small differences in nutrient availability from crust formation. Brouwer (1996) identified the important interactions between rainfall, soil water, nutrient availability, and spatial variability. He found that the spatial variability of rainfall meant that while water may be limiting in some parts of a field, nutrients may be limiting in other parts (where there is still water stored in the soil). Spatial variation in infiltration rates enhances these patterns (Cuenca *et al.*, 1997; Matthews, 1998) and Davis *et al.* (1995) attributed the spatially variable levels of soil phosphorus levels to this effect.

However, significant importance was attached in these studies to plant and soil interactions (refer also to box 5.11). The vegetation creates micro-environmental niches and farmers have been observed to exploit this to reduce risk (Brouwer *et al.*, 1993; Hermann *et al.*, 1993). Pieri (1989) found higher concentrations of N, P, and K+ under shrubs as a result of nutrient cycling, as well as higher concentrations of organic matter. A feedback process decreases soil acidity and enhances environmental conditions for biological activity (Breman and Kessler, 1995; Schlesinger *et al.*, 1996). Herbrig (1997) found that the most significant soil improvement was within a radius of 50 cm, and to a lesser degree within 150 cm around small bushes in the region. The research also found different shrub species produced different enrichment ratios. Kainkwa and Stigter (1994) found the difference to be pronounced between individual isolated species of different shrubs and trees. Wezel *et al.* (2000) found the highest rates of enrichment for C, N, K+ and Ca^{2+} under *Piliostigma* spp. This may have resulted from differences in nutrient concentration and mineralisation of leaf litter (Charley and West, 1975). Alternatively, it may have resulted from differences in the quality of the foliage (Wezel *et al.*, 2000): *Guiera senegalensis* is a tall shrub with a densely foliated crown, whereas *Piliostigma reticulatum* is small and more compact with dense foliage. These characteristics of *Piliostigma* make it more favourable for trapping aeolian sand and dust than *Guiera*. Differences in stemflow may be another explanation (Whitford *et al.*, 1997). Charley and West (1975) found *Guiera senegalensis* (the most common shrub in Fandou Béri) to improve pH. Crops in sandy soils are very sensitive to small pH variations, and observations by Wezel *et al.* (2000) found *Guiera senegalensis* to influence the exchangeable base status of these soils. Higher nutrient status was also described round various tree species (Kellman, 1979; Bernhard-Reversat, 1982; Belsky *et al.*, 1989).

Although research has provided detailed ecological understandings of variability, one of the primary aims of the orthodox agro-scientific approach has been the control and reduction of spatial variations in soil quality whereas the local farmers' management relies on these variations. The most striking contrast is the conflict between the local flexible management strategies and the inflexible approach of the formal crop breeding programmes in the village. Research by Brouwer and Powell (1998) confirmed the value of targeted plot-scale practices; they found nutrients could be used more efficiently if application rates were adjusted to small-scale variations in the landscape and field topography. Hiernaux *et al.* (1999), Ikpe *et al.* (1999) and Powell *et al.* (1998) have also shown the benefits of targeting livestock urine as well as to manure applications.

The above sections showed that while the smallholders in the study considered themselves to be either farmers or herders, all kept some livestock and grew crops and employed local knowledge accordingly. Almost all cattle and small ruminants spent some time grazing fallow, and had their diet augmented with crop residues. All the farmers operated a nutrient management system where crop and livestock production systems interacted. The scientific concept of 'nested nutrient cycles' is applicable to all the farmers in the study (nutrient cycles were introduced in Chapter Two (section 2.2.4). However, as the next section shows, each farmer emphasised different aspects of the cycle in his particular management system, depending on his choices and priorities.

5.4 Choices and priorities for soil fertility strategies and investments

This section presents farmers' narratives of the choices and priorities they attach to their management of natural capital, in particular to soil fertility. The variety of methods to improve soil fertility, as outlined in section 5.3, is the result of different choices by the farmers. The farmers believed that flexible soil fertility management was the key to maintaining crop yields. They argued that flexibility and choice were important because their assets and resources were constantly changing. The decisions themselves in turn affected the resources and in consequence, the choices for soil fertility practice also changed.

The relative importance of any one method of soil fertility maintenance was different for different households. In the farmers' decision-making process, choices and priorities about natural capital were subjected to multiple influences. These influences included aspects of their lives that had little to do with natural capital. They described influences that came from all the capital assets in the Sustainable Livelihoods framework: natural; human; social; economic; physical; political; and institutional. In this section, case study extracts are presented in boxes, describing the farmers' perceptions of choice and priority in their choice of the most commonly discussed methods of managing soil fertility: bioproductivity; labour; cash; land and tenure; social status and lineage. Rainfall was considered by the farmers in the study to be the driving force behind farming practice. Case study extracts on the role of the rains have been presented in section 5.1.

Rainfall has a special interaction with micro-variations in natural or environmental capital, as outlined in 5.3. These factors included the farm's biological resources, spatial variability, soil type, and the past land use and investment. Together they compose the bioproductivity of the land, according to the farmers. Perceived bioproductivity was the foundation on which farmers attached value to soil investments and nutrient applications, targeted at plot-level (box 5.19).

BOX 5.19: FARMERS' PERCEPTIONS OF THE EFFECTS OF BIOPRODUCTIVITY ON CHOICES FOR SOIL MANAGEMENT

Amadou Oumarou had different priorities for soil fertility investment based on the soil class in each field. He made higher investments on his *botogo* and *gangani* soils than on *tassi*. He put the sandy soils in fallow in order to allow the soil to develop fertile *korobanda* crusting. Dung was left on the sandy soil when Fulani left their animals to feed on the crop residues. The time that the animals spent grazing was the subject of a gift exchange, for he did not pay for it. He had 13 animals of his own which he corralled on the *tassi* field before the planting. He moved them to the fallow after the planting of beans. His management of this fallow was based on variations in bioproductivity. He was aware that bushes trap dust and improve the soil and preferred to keep bushes on the good soils until he had begun planting and the seedlings had developed. He then invested in extra labour to cut the branches and burn them on the fallow patches, considering this a particularly good investment where there were low-lying silty soils that were prone to damage from the early season storms.
Hamani Djibo chose to prioritise his investment in a different way to Amadou Oumarou. He believed that the poor sandy soils needed more investment than the better soils. This might be a reflection of the location of his fields – the closest fields, which he worked more continuously, had poorer sandy soils. On poor soils he used a greater variety of soil improvement techniques and encouraged Fulani to graze their animals on the crop residues on these fields at the end of the season. However, despite the higher level of material inputs on these soils, he spent most of his time preparing the other soil types. His labour investment for soil preparation on the sandy fields was four days per season as against twenty for other fields. Even on his good fields however, he believed that there were limits to labour investment and 'much is dependent on Allah and the timing of his rain'. He considered that crop failure from drought on the sandy soils at the beginning of the season was his most serious risk, but crops on the silty *gangani* were more vulnerable to late season drought.

The farmers' perceptions of bioproductivity at the end of each season were key to the choice of soil fertility strategy for the next. The strategy had to justify investment according to the farmers' perception of the bioproductivity status at the time of the decision. Those farmers who considered themselves to own relatively fertile fields, believed strategies for management could rely on fallow and grazing, while those who owned soils considered to be infertile gave higher priority to costly improvement practices such as transporting manure and composting. However, farmers' perceptions of the necessary treatment for soil fertility improvement based on the bioproductivity cannot be used as an indicator of practice because there are other complex socio-cultural issues, discussed later.

All the farmers cited the additional yet pivotal influence of rainfall on labour prioritisation (section 5.1). For families in the study, labour mobilisation transcended any other aspect of human, social and economic capital. The farmers perceived the size and quality of their family labour force to be critical in deciding possible soil improvement practices (box 5.20). Large families, with several sons, were in a strong position to use labour-intensive strategies such as applying manure and recycling weeds, while small families were dependent on assistance.

In addition to choice based on household demography, box 5.20 shows that farmers perceived other factors to be related to labour mobilisation and access to help from outside the family. These included skills and experience and a farmer's ability to mediate local labour exchange or hire extra paid labourer. Since labour has not fully entered the local market as a commodity, paid assistance was uncommon for adults in the village. While boys were hired for help with peak demand periods (e.g. land clearing or weeding), only the poorer farmers diverted labour away from their own farm to undertake paid manual work in the village. It was clear that the farmers made a distinction between paid work and labour exchange. Labour exchange or 'work parties' carried no stigma and while mostly an arrangement between small kinship groups and neighbours, access to this form of labour was critical to the successful completion of farm tasks, especially for small households. However, what mattered to the farmers interviewed, was not their household's absolute endowment of labour, but the skill in matching labour to land, access to networks or ready cash for hired assistance at critical periods after rainfall and the partitioning of rainfall (box 5.20).

BOX 5.20: FARMERS' PERCEPTIONS OF THE EFFECTS OF LABOUR MOBILISATION ON CHOICES OF SOIL MANAGEMENT

Moussa Soumana maintained that, with his large family of three wives and 11 children, he was able to make better decisions to allocate labour than he would without them. His decisions focused on labour management and he ranked decisions about labour as the most important for his farm. He considered failure on the farm to be related primarily to poor timing of labour activities in response to the rains. He had a sandy field close to the village, which he seeded and weeded before his *botogo* and *korobanda* fields. He chose to use short-cycle millet cultivars on the sandy fields so that he might spend longer preparing these soils and could then wait until the larger rains before he sowed. He claimed that he was able to do this because the family was able to mobilise a large labour force quickly. He said that his neighbours were forced to sow at the first rains, even if they were not sufficient, because they did not have the labour to sow large areas quickly.

Farmers with small family labour forces suffered serious constraints if they became ill during critical labour input periods. *Hassane Malam* became ill at the beginning of the 1998 growing season making it difficult to work. A shortage of grain in the family granary resulted in their not being able to eat for three days before completing their grain buying. He was unable to return labour exchange at the time when villagers offered to help and was forced to pay to hire three boys in the village to clear and weed. Consequently, he was unable to buy any further grain for re-seeding after early season failure. It was not a good start to the season, but he was able to rely on family to maintain a decent crop until he was better by the time the second weeding was needed.

The skill in matching labour to land requires local knowledge of farm bioproductivity, and then the prioritisation of these targeted soil improvement practices based on a consideration of the household's physical capital. Aspects of physical capital, perceived to be important to practice, included the size and spatial distribution of the farm. The farmers believed that these were factors that affected their labour costs. They pointed to the extra demands on time and energy required in walking to out-fields compared to village-fields. If they have further to walk, they reasoned that it was less likely that a labour-intensive strategy could be used. Some farmers with large farms claimed that while there were labour constraints, they were able to fallow larger areas, while still maintain subsistence yields. They felt that farmers with small farms would need to borrow land if they were to rest much of any one field. The smaller farmers themselves, however, claimed that fallowing was not a high priority, if they had sufficient labour or livestock, because tenure exchanges did not favour fallowing. Farmers who borrowed land, including the Fulani (who work only borrowed fields), preferred to corrall animals or add manure rather than to leave any significant part in fallow. To leave one's own land in fallow was not controversial but to leave a borrowed field in fallow would invite the owner to reclaim the land, according to the farmers in the study. These social complexities, tied up in land tenure, land rights and identity, induce farmers to select different priorities for different areas of their farm (box 5.21). These and other tenure issues, such as accessing land through networks, are discussed further in Chapters Six and Seven.

BOX 5.21: FARMERS' PERCEPTIONS OF THE EFFECTS OF TENURE ON CHOICES FOR SOIL FERTILITY MANAGEMENT

Djibo Abdoullaye had a series of disagreements with neighbours over a field he had been borrowing. The conflict began after he had left part of the field in fallow because he claimed the soil quality was poor and the millet yield was low. His neighbour felt that the land should be returned to him because he would be happy to farm it instead of leaving it in fallow. Djibo Abdoullaye returned the land in 1998, following the judgement of the village chief and borrowed another field from a different neighbour with which to supplement the yield from his own field. He said that he would not be leaving any of the new field in fallow while he had access to it, despite the probable reduction in quality, in order to reduce the risk of conflict. The entire field was cleared and burned in February 1998. He hoped that he would have access to enough land to continue fallow rotation on his fields because although land cannot be bought he hoped that he could rely on borrowed land from his family.

Oumarou Moussa owned two fields, but both were poor quality sandy soils and neither was particularly close to the village. He therefore had come to an arrangement with several neighbours to borrow plots of land from them for a few years at a time. He fallowed only his own land and the plots that were borrowed were never put into fallow. To maintain soil fertility he occasionally used animal corralling on poor areas and kept sheep and goats on the field during the dry season. He grew mainly cash crops on the borrowed fields, dividing his labour between all the fields to maintain the appearance of necessity to the landowners. He openly admitted to currently investing only in his own fields, although he depended on the other fields for income. He was unable to purchase more land, so that there may come a time when he begins to invest in the borrowed fields. He believed that mineral fertilisers would benefit some of the borrowed land. He was aware that if the land were to be returned to its owner because it was no longer productive, he might not be able to secure replacements. He believed that land was increasingly in demand and had been in conflict with one neighbour over a boundary plot that had lapsed into fallow. The village chief was required to settle the dispute. Oumarou Moussa lost the field.

The farmers perceived a variety of other social factors to also be important to their choice of practice. They referred to the effect of a farmer's social status or lineage on his ability to secure access to additional labour or land, cash, carts or nutrient inputs from livestock in discussion. The process of organising labour exchange reinforced the farmers' opinions about the importance of social status. Those with several wives had additional access to labour from the extended family. Many farmers also described what they saw as a link between social status in the village and improved access to outside assistance and knowledge. Box 5.22 presents some of the farmers' opinions on these issues. Those who had co-operated with researchers in the past or had access to government agricultural agents were perceived to pursue more diverse improvement practices. In addition, the farmers saw social identity as a determining factor in access to knowledge. For example, the choices considered 'open' to farmers differed according to whether they were Fulani or Djerma, although many farmers in both groups practised mixed farming (box 5.22). Specific cultural knowledge was seen to influence the way in which they were able to prioritise investment in soil fertility. Some farmers also perceived differences in prioritisation between farmers of different ages (box 5.22).

BOX 5.22: FARMERS' PERCPETIONS OF THE EFFECTS OF SOCIAL STATUS AND IDENTITY ON CHOICES FOR SOIL FERTILITY MANAGEMENT

Marou Soumana was a Fulani farmer who arrived in Fandou Béri to settle some years ago. A Djerma farmer in the village lent him a plot of land for his family to live on. He had been growing pearl millet and beans, and hibiscus next to his hut. He claimed that the tenure arrangement was good, but the owner did expect him to farm most of the field to show that the loan was appreciated. He said that he was happy to be Fulani and be able to apply high levels of manure because this allowed him to cultivate most of the field continuously. He knew that most Djerma farmers in the village did not have this luxury and were dependent on fallow, burning and only a little manure. He owned a large migrant cattle herd of approximately 141 head, which were cared for by other members of his family. He was able to make his animals his key soil fertility maintenance technique on sandy soils. Some of the herd was brought back to graze the crop residues at the end of the harvest and some remained on a small patch of fallow during the rainy season. This fallow patch was kept for two years then moved to another area. The animals were often corralled in certain parts of the field where yield had dropped. He had learned techniques from his Djerma neighbours, so that in addition to his manuring, he now used mulch, compost, legumes and also, on occasion, burns. When there was a good rainfall, there were good yields. His strategy had proved efficient and he sold some his crops in local markets. Together with the income from his animal breeding, he could afford to pay local boys to weed the field during July and August.

Hassane Malam claimed that his family was one of the first Djerma families to settle in the village. His household was made up of 27 members of extended family, which gave him plenty of family labour but also put great pressure on his land. He was one of two holy men, or Marabout, in the village. He led the second prayer. His social status was reflected in the position of his largest field, which was located close the village and next to the main well. Herds passing through the village frequently stopped at the well, so that his field, which was continuously cultivated and had poor sandy soil, received regular manure in spite of the fact that he had few animals of his own. His position had also given him access to information and aid. His family was invited to co-operate with an extension project that worked in the village in the 1980s and he spent eleven years benefiting from the scheme, one of the longest associations.

Adamou Garba, a young farmer, claims that he would like to make different choices for soil fertility investment to those of his father. He said that his travels while working on the Ivory Coast showed him new ways to farm. He would prefer to work one good quality smaller plot of land and keep it manured by his animals or with mineral fertiliser, but unfortunately the land he had been given by his father was fragmented and of poor quality. His believed that fallowing this soil was not enough to raise its fertility and his priorities for investment focused on hiring labour to work more intensively the better areas of some of the fields. The remaining fields were fallowed and Fulani herds encouraged to rest on them. He experimented with different planting densities for legume crops and left plots with bushes until after planting.

The last influence on choice and priority to be discussed is farmers' access to cash. Although the influence of cash is complex, as box 5.23 illustrates, many farmers perceived it to be a solution to any constraint. The farmers believed that they had more choice if they were able to hire extra labour at short-notice, pledge cash for land, or invest in livestock. They saw cash from migrant work, small-scale business or petty trade as a solution to labour shortages and as a means to sustainable practice. All the farmers considered the village economy to be weak and most considered their household to be cash-poor. They believed this impinged on their ability to make the choices they wanted. Cash-poor farmers cited output local markets, the prices of inputs such as fertiliser, the market price for crops, and access to credit as other influences on their choices. However, while low income is a limit to many farmers' ability to invest in farm capital, technologies are accessible without cash, through networked exchange systems. Issues of access using these measures are explored further in Chapter Seven.

BOX 5.23: FARMERS' PERCEPTIONS OF THE EFFECTS OF CASH ON CHOICES FOR SOIL MANAGEMENT

Amadou Soumana was a Djerma farmer who did not have a large family but his household did own 90 livestock. Some of these were cared for by local Fulani herdsmen, but he was able to corrall the small ruminants on the fields during the dry season. He regularly travelled away from the village during this time to earn money from working in the Ivory Coast. He invested some of the income he made in this way in additional manuring, paying local Fulani 2500 CFA to keep cattle on the fallow in October 1997. He believed that he was lucky to have the means to intensify his farming on the fields that produced the best crops. These fields were also the closest to the village and the ones he relied upon for his subsistence crop. The extra capital he was able to command also meant that he could buy more millet seed than otherwise. He purchased local millet varieties because he considered them to be hardier than the 'red millet' short-growing landrace. He was able to replant more of his field because of the early season low rainfall and still get a good crop. He chose to call fallow 'the poor man's method' of soil improvement. He believed that he had more choices and was able better to prioritise his investment to the farm than others. For example, he rarely had to abandon plots to fallow because he could afford to pay local boys to weed the fields, despite his own family labour shortage. He believed that his labour situation would improve as he planned to have more children and as those he already had grew up to work the land with him.

Ide Abdoullaye had an above-average income and often produced more crops than his family needed. He was able to sell the surplus and make a return on his labour investment. Although he was Djerma, he had 22 head of livestock and therefore did not think that his farming was constrained by a lack of inorganic fertiliser. His participation in the mineral fertiliser scheme in the 1980s had given him bumper crop yields and made him aspire to keep good yields and good profits. He could no longer afford this strategy and had now integrated small livestock into the farm system to help to improve soil fertility, and increase the low yields that followed the droughts of the early 1990s. His soil improvement technique now depended only on his animals and he was happy to be independent of Fulani. Despite his optimism, and the high soil fertility of his silty fields far from the village, he was worried that his sandy fields near the village might be losing nutrients in the long-term. He considered these areas of the land to have an 'illness' that his cattle alone could not cure.

Yssaka Souley owned only *tassi* fields and was dependent on his family for labour. The fields had high rate of erosion (44.23 t/ha/yr) and low organic matter in his opinion. To maintain yields he had borrowed a field from a friend so that he could rest his own in fallow. He owned two small ruminants that were kept at the homestead and their manure was transported to the closer fields, but he considered transporting the manure time-consuming. The sandy fields had many weeds that indicate poor soil. He considered grasses to be more productive than bush on fallow land because he could graze animals on them, but in reality he might have little to compare his fields with as they are not fallowed long enough for bushes to establish. He would like to have had the Fulani graze cattle on his fallow field but could not afford to pay the price they were asking. He had sent his son to a religious school in Niamey. He claimed that this is for him to learn a better future.

Hamani Salifou had the lowest income in the sample group. He claimed that he was unable to meet his households subsistence needs. His wife earned a substantial proportion of the household income through the sale of firewood and domestic products. This money was not invested in the farm at large, although his wife did invest some of it in her plot of land. He relied on the contribution that she was able to make to the soil fertility improvement through gardening of legumes. His main soil fertility practice on his three sandy fields was fallowing and burning. He claimed that *gangani* hard pan had appeared in a field he had cultivated for ten years and he composted this area in order to continue growing millet, sesame, sorghum and hibiscus. He made maximum use of the spatial diversity on all the fields, planting where the fertility was better. This greater fertility was usually as a result of the bushes and trees that marked the field boundaries. The household had a few animals but they were stabled within the compound and the manure had to be transported to the fields.

This section has presented the complexity of choice and priority in natural resource management, as perceived by the farmers in the study. They identified a dynamic process of investment decision-making based on an ever-changing portfolio of livelihood structures and assets. Although the discussion has focused on choices and priorities for investment in soil fertility practice, flexibility was required in decisions for natural resource and agricultural investment or land allocation more generally. The farmers' capacity to balance idealised perceptions and respond to a complex set of constraints and opportunities only serves to reinforce their identity as skilled risk-managers. The very nature of this flexibility and complex multidimensionality, at the intra-household scale, means that farmers' responses remain specific and individual. Box 5.24 presents one such example, with a case report of one farmer's 1998 agricultural season.

BOX 5.24: ONE FARMER'S AGRICULTURAL SEASON

The local narratives of flexibility, centred on the rains, demonstrate that each farmer has his own preferred strategy for managing specific types of adversity. Choices that are made for natural resource use rely on experience and an intimate knowledge of the farm, as the following case study shows.

Kadri Yaye was a middle-aged Djerma farmer. His family came from an early lineage in the village. He inherited three fields of different soil types from his father. Two of these fields were of low productivity, being predominantly low-fertility *tassi* soil with some pockets of silty *botogo*. His third field, in the middle of the territory, had a sandy soil with a hard crust that was difficult to work (*gangani*). He considered the largest mixed-soil field nearest to the homestead to have the lowest soil fertility and to be the least productive because it had been continuously cultivated for over fifty years.

With a below-average household annual income he could afford only to put manure from his two livestock on one field and chose to put the animals on the low fertility field because its proximity to the village reduced labour demands. He was dependent on leaving the low fertility parts of his fields to rest in fallow rotation and laying crop residues on the surface to decompose (mulching) for soil improvement.

Kadri Yaye relied heavily on help from his family and two sons to run the farm because he had never been able to afford to pay others to help. He admitted that labour bottlenecks at critical times in the season had always been difficult to manage. His family was dependent on the farm producing a minimum of 330 bundles of millet to meet subsistence needs until the next harvest. The 1997 season was a particularly stressful year for Kadri Yaye. The previous few years had seen drought and unreliable late-season rains and 1997 was no exception. The lack of rains had failed to reduce the grasshopper population and swarms had eaten his young millet crops after each sowing. Most of the farm had been abandoned and his family had harvested only 146 Bottes.

After the harvest Kadri Yaye left the village and travelled to friends in Ivory Coast to earn some money in non-skilled manual work through the dry season. He returned in February 1998 with enough money to purchase seed while it was still affordable (his family had eaten what should have been seed). He spent a month cutting and placing the last season millet stalks and the branches from *Guiera senegalensis* bushes on the fields to protect the exposed soil from the early season winds and to attract termites. Slow burning in the sheltered area of his large field reduced the risk of parasite attack in the early season and probably helped to release local concentrations of phosphorus, calcium, magnesium, potassium and even nitrogen. The timing was critical as ash also increases the alkalinity of these acid soils and burning too close to the early rains carries the risk of having the ash washed away. However, early storms did not come when he predicted.

Experience had told him that the sandy soils would be more productive in another dry year and consequently he decided to clear a three-year fallow on his large *tassi* field. He chose not to dry-seed his crops this year in anticipation of rains because it was considered a risky strategy and he had precious little seed. He decided to miss the chance of a first flush of nutrients with the first rains. He decided to carry manure to his *gangani* field and distribute it. It came from his household livestock. The field was over two kilometres away from the homestead, but he hoped that with additional organic matter the surface would be easier to work. The previous year he had persuaded local Fulani to graze cattle on this field's crop residues for two months after harvest, but this year he would not be able to afford the 7,000 CFA payment.

The first rains in 1998 followed a large dust storm on the afternoon of the 30th April. He and his family planted the millet seed on the *tassi* parts of the large field three days afterwards. The reasons he gave publicly for the delay was the belief that the next rains would be over two weeks away, but privately the reason had been because labour had been diverted to clear a four-year fallow along a boundary to prevent a dispute with his neighbour. This was unusual since boundary land is rarely left in fallow for more than three years. He had misjudged the cloud formations and was unlucky as the next rains fell on the 7th and 17th May and he was not ready to sow until the 19th. He then planted a fast growing millet cultivar (known locally as red millet) on the *tassi* fields.

He partitioned his labour so that during May and June the work was focused on the *tassi* fields, and thus he abandoned his preparation on the fields with other soils. The young millet crop was thinned and beans intercropped in the area just cleared from fallow and in a small area that his wife had cultivated the year before. He chose to plant different crops on the different soils and fields reflecting their fertility and moisture-retention capability. Planting density reflected soil microvariability. As rainfall frequency improved later in June and July, he redirected work to planting on the *botogo* and *gangani* fields. The *botogo* soils were additionally able to support sorghum, sorrel and hibiscus planted at the same time as the millet and he planted groundnuts on these other soils fifteen days later. Because much of the farm's *botogo* soils had not been prepared he was unfortunately constrained to cultivating only those parts already ready. There was not enough time to clear the *botogo* field and sow the crops as well as tend to the developing crops on the *tassi* soils. The fallow area on the *botogo* soil was increased as he began to weed the cultivated areas. High levels of weed growth, including *Striga* varieties, had resulted from the improved rains in 1998 and several parts of the worst affected areas were abandoned in the second weeding. Overall 1998 had brought more sustained late-season rains and he hoped that he would be able to work in Niamey after the best harvest in several years.

Kadri Yaye considered labour and access to manure to be the most serious constraints on his farm's productivity. Much of the decision to clear early season fallow was a result of these constraints, whereas the clearing of late season fallow was a result of rainfall distribution and equalities in soil fertility over the field. His limited labour resource made his priorities for action especially difficult and made him vulnerable to unpredictable rainfall patterns. The previous end-of-season's low capital resources had resulted in a complex set of problems and constraints in other essential resources, such as seed, manure and labour.

Understanding the ways in which smallholders see their farms, and consequently make choices and priorities, is developed further in the next section. The use of visual geographies in this section aims to order the current picture of complexity in natural resource allocation and investment that has been developed in this section. The presentation aims to provide a more structured view of diversity based on individual local knowledge and capital assets as perceived by the farmers themselves.

5.4.1 Cosmologies and metaphors

Visualisation techniques were used to allow farmers to lead the discussion of land use and investment. The technique recreated a great variation in the kinds and depth of such knowledge. The choices made by individual farmers depended on their capacity to enact successful agricultural performances and to exploit an evolving range of opportunities, and these in turn were based on the use of their knowledge, as well as on their communication and creative capacities. Specific local knowledge, here as elsewhere, becomes intertwined with the belief and value systems that underlie culture (Pawluk *et al.,* 1992; Stoller, 1989). Two examples in boxes 5.25 and 5.26, show the use of cosmologies and metaphoric linkages in the soil fertility discourse in the Fandou Béri (see Orlove *et al.* (2000) for scientific analysis of farmers' use of constellations).

BOX 5.25: COSMOLOGIES AND LAND-USE

Farmers used the location of star constellations to confirm the stages of the agricultural calendar. Many Djerma were reluctant to discuss their observations in conversations with other farmers, preferring instead to display their knowledge of technically 'important' topics. Only individually were they enthusiastic about the role that cosmologies played in their decisions. Fulani farmers appeared to have a greater sense of detail when describing cosmologies, perhaps because they are more important to their identity.

Two main star constellations were described. The first was described by Fulani farmers and reflected the quality of the rains. Known as *calma*, a group of stars appeared like a spade or a large tree. When these stars are visible during mid-June the rains should improve and the plants grow well. The rains usually come four days after the stars move to a position that represents the spade upright. If the stars disappear, the farmers predict drought. The second example is a group of stars, collectively known as *doubi*, which appeared approximately seven months after the harvest. The farmers closely watch these stars because following their disappearance they should wait a week and then sow some of their crops. The disappearance indicates the arrival of dust and a small rain in one week, followed by a second rain in two weeks. These rains give 'hot' soils, ideal for planting. Then after thirty to forty days the stars return, bringing a larger rainstorm. Two Djerma farmers interviewed also told of using this information, which they say they had heard from their Fulani neighbours.

BOX 5.25: METAPHORS AND SOIL FERTILITY

Elements of metaphor can be found in the ordinary discourse of farmers about soil fertility and choices for land investment. Soils are described as 'hot' or 'cold' depending on whether it has rained and made the land fertile to sow. The fertility of the land is described in terms of its health, and allusions are made to the age of the soil in cultivation. Soils that have been in cultivation for long periods are described as 'sick', 'old' or 'tired' and seriously degraded areas as 'dead'. Soil recently out of fallow or cut from bush (*saji*) was described as 'young', 'fertile' and 'healthy'. The farmers describe the land as 'alive' and 'hard'. To describe land as 'alive' indicated that it is a living, and productive, part of their environment that needed respect. The land is also part of the local beliefs of the cycle of life and several farmers discussed spirits living in their land. Hardness is an acceptable quality to Djerma and therefore although working the land is 'hard' it is an acceptable challenge. Many farmers continue the analogy of life in describing how the soil and plants 'talk' to them. To maintain young and fertile soil requires respect, patience and hard work and these are considered the virtues of a wise farmer.

5.4.2 Visual geographies – mapping individual perceptions of choice

On an individual basis, knowledge was acquired through personal experiences and overlapping communication pathways, both of which were influenced by social factors, including age, gender and family ties. Uncertainties arise because any one farmer's knowledge was incomplete and incapable of dealing with risks outside of their partial perspective and this created a plurality of perspectives. For example, an overlapping set of influences affected knowledge distribution and communication.

One of this set was familial status, based on lineage and traditional divisions. Family ties can allow access to specialised spheres of knowledge and sources of income that are not available to other members of the community (for example, in association to the chieftainship or contact networks that permit the exchange of travel information). These preferential patterns may be built upon if wealthy farmers are sought out by external agents and given privileged access to information or treated as the most likely candidates to adopt new technology. They may influence the construction of research typologies, if they are perceived as opinion-leaders in their community. But the traditional belief system and its associated practices was not equally spread in Fandou Béri, and appeared to be eroding in importance in for some, especially the young, who voiced interest in entering new professions.

Thus each farmer had a distinct, individual ability to apply knowledge, and so to create an individual response to the constraints and opportunities of their agricultural situation. On a small scale, network 'mapping' can capture some of these everyday local experiences which create 'common' knowledge to those who experience them. This is because the network maps gave farmers the opportunity to create imaginative visual geographies of farm work through the rainy season. By drawing symbolic maps in the sand during discussion, they gave images to conceptual processes. As activities could be drawn in the sand as pictures or symbols rather than as text, the farmers were able to control communication and representation. The maps represented their perceived linkages in choices and the priorities that influenced their allocation and investment in land. Replicating these diagrams on paper permitted farmers to make additions to their map through the course of the growing season. Box 5.27 presents the maps of four individuals completed in 1998.

The maps identify the complex links that exist in soil fertility practice and the conceptual arrangement of knowledge or differences in management between individuals. This management was seen by the farmers to relate to land use decisions; the influences on the decision to fallow, to cultivate, or to invest and the differences between forced and deliberate fallow. The varying levels of complexity in the diagrams represent the opportunities and constraints, perceived by that individual, that influence on these decisions.

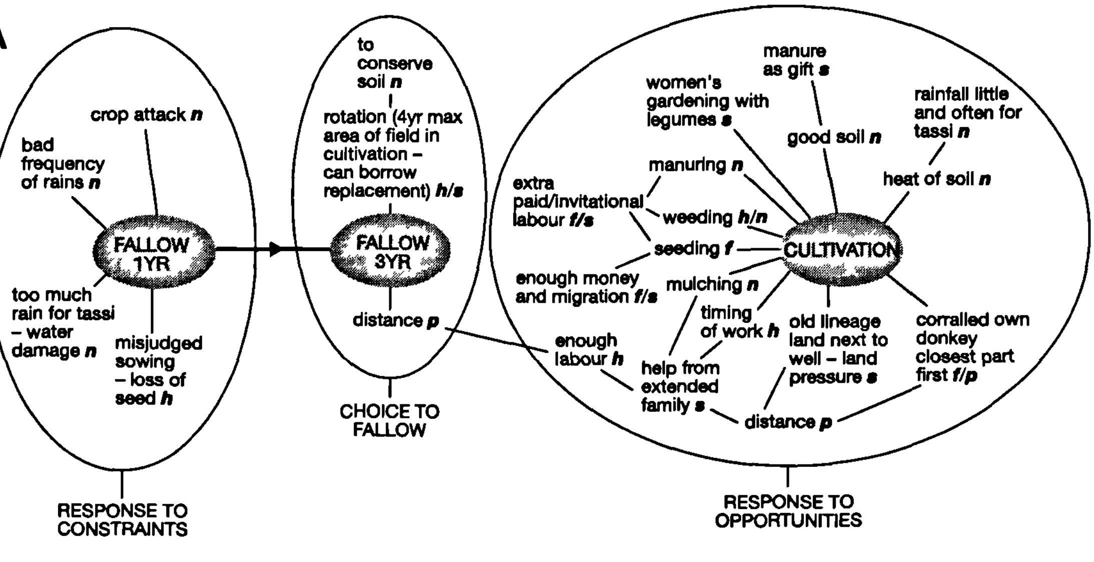
Box 5.27: NETWORK MAPPING

***s** social* networks, status, trust, access to institutions
***h** human* knowledge, skills, ability to labour
***f** financial* credit, savings, income
***n** natural* soil, water, biodiversity
***p** physical* distance, infrastructure, tools

Key to information based on farmers' 'capital assets'

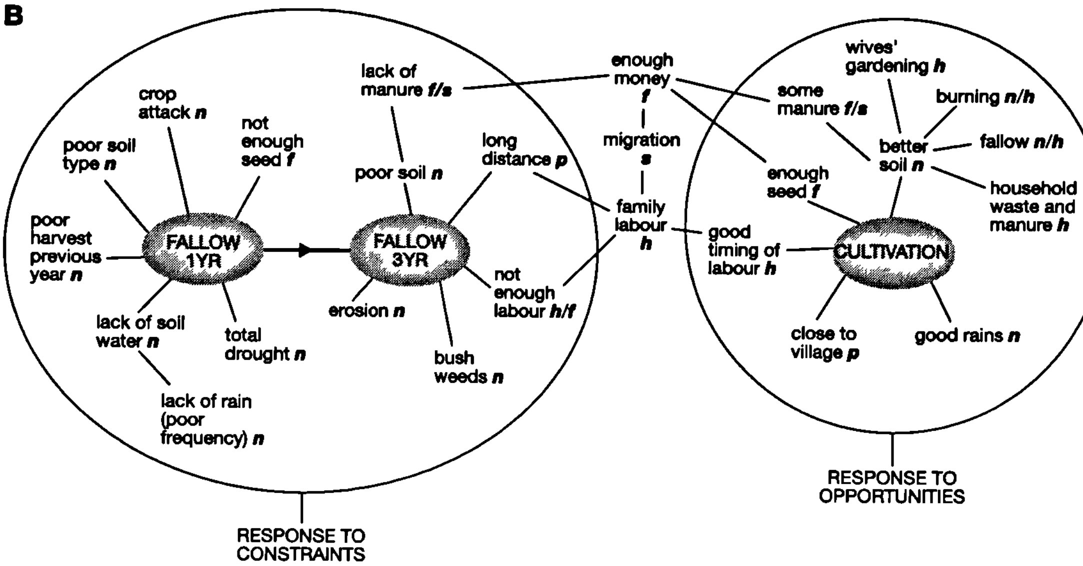
The 'map' for farmer A reflects the social and financial asset opportunities open to a farmer with status in the village (a marabout and old family lineage) and *tassi* soil management (his only soil type). He received income from maraboutage as well as gifts of manure, labour and credit from friends and family.

A



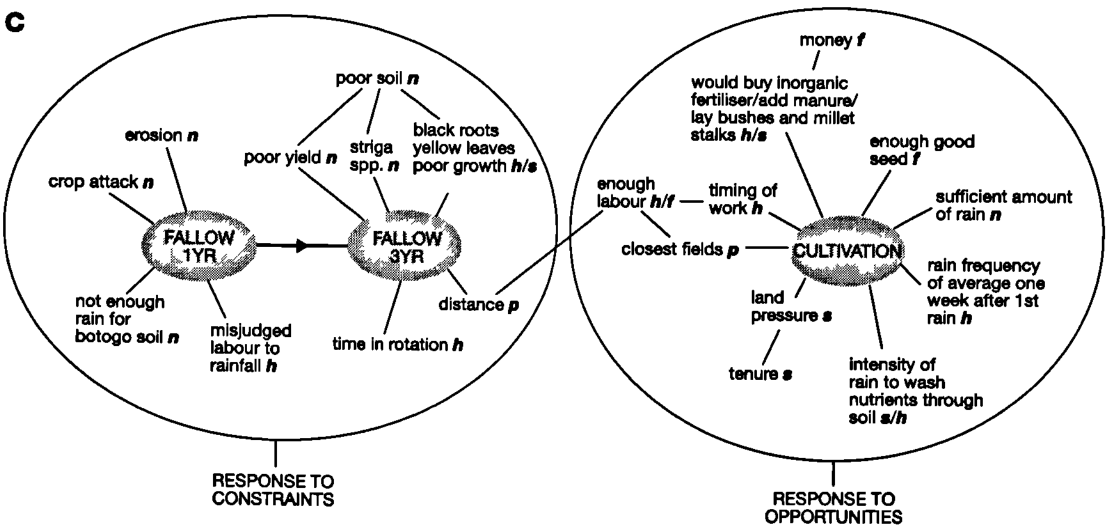
Farmer B identifies many more constraints, he has limited social, financial and natural assets (a lack of access to credit, low income, and poor soils). The 'map' shows his concern over labour and capital constraints, which limit the soil fertility management opportunities available to him. To compensate for these constraints he undertakes seasonal migrant work for cash.

B

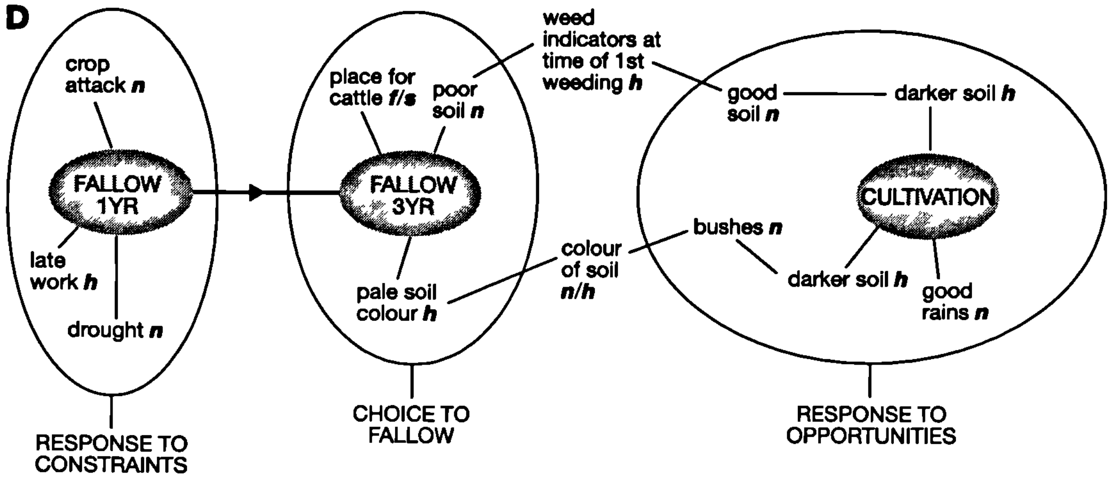


Farmer C had created opportunities through social and human assets, such as links with extension projects, or mediating tenure and labour access, in order to balance his limited financial assets, and the perceived importance of these assets for his soil management is shown in the 'map'.

C



In contrast, the simpler network 'map' for Fulani agro-pastoral farmer D highlights the human assets gained from pastoral experience, primarily his specific skills and knowledge of plant-soil-livestock interactions. A reliance on livestock inputs is indicated by an absence of alternative inputs strategies to make cultivation possible. In addition, the 'map' suggests that labour shortages at critical times of the farming season were an important constraint, as were other constraints beyond his control.



Box 5.27 illustrates how individual agricultural performances were dependent upon individual perceptions, assessment and skills when responding to real-life conditions. The maps show common agricultural themes of fallow or cultivation activities, dictated by the rains, but the linkages are very different. The resulting levels of complexity in the network diagrams are of particular interest, because they represent the complexity of the opportunities and constraints perceived by each individual. The household's livelihood portfolio or the predominance of particular types of 'capital asset' defines these opportunities and constraints. Hence, the conceptual importance attached to soil fertility investment for farmers with poor soils and little access to livestock or labour was defined by constraints, whereas for farmers with exogenous knowledge or with higher social status, it was defined by opportunities. Additionally, the maps make it clear that fallow was perceived by farmers to result from choice but also constraints, a 'forced response'. The 'forced response' was emphasised by farmers with poorer soils, and less access to livestock and labour. These farmers made greater numbers of linkages when valuing their land and this was represented in their 'maps'. However, the complexity of choice was not perceived by the farmers to be related to wealth.

The generic aspects of a Sustainable Rural Livelihoods Framework were used to code the information in the farmers' maps. This provided a method of structuring the diversity and a means to compare the maps. The code, as shown in box 5.27, refers to the key 'capital assets'. The relative abundance of each 'capital asset' in the map can be compared, showing the importance of different 'capital assets' to different farmers. Thus the maps become statements about the way each farmer views his farm management, but also a reflection of their status, identity and fears (box 5.27). These maps also represent individual perceptions of ownership or the entitlement mapping of endowments. This is critical to understanding how different people derive entitlements from endowments. The maps illustrate why endowments cannot be assumed to be 'given', as it is clear that people's perceptions and capabilities influence value and access to resources.

The maps show that at the local level, the inherent temporal and spatial heterogeneity of natural resources is paralleled by an equally variable set of social resources (including knowledge, labour availability, production objectives, and the personal attributes of individual managers). The farmers referred to 'cultivation' in the maps as *mise en valeur*, which translates as *exploitation*, giving a valuable insight into local perceptions of agriculture as 'taking opportunities'. To work with environmental micro-diversity, the maps demonstrate how the farmers develop an understanding that allows them to manage dynamic social, economic and environmental resources, and this knowledge may often appear to run counter to the understandings of conventional agricultural science. Their perspective essentially incorporates the ephemerality of soil status, the historical dynamics of soil fertility and the need for soil fertility maintenance to reflect natural variability. They are able to respond to the evolving set of physical and social conditions within each year, from one year to next (see box 5.24). The farmers had 'best' practice plans, but were often unable to carry them out because of their costs (in terms of labour or time). Thus, local soil fertility management is the result of a combination of responses to unforeseen events, planned management, land use history and the farmer's own particular knowledge. These form the basis of a household's coping tactics at a particular time, in a specific place, whereby local knowledge is employed in an array of methods to manage soil fertility depending on the household 'capital assets'.

One problem has become clear through the analysis of individuals' perceptions of their everyday farming activities: descriptions or models of responses to past stresses cannot necessarily be used to predict responses in the future. The maps are temporally dynamic. However, that does not prevent their being useful for understanding the real-time behaviour of farmers during a specific agricultural season. As the previous sections have shown, there were many different activities through this season: decisions regarding where, when, how and what crops and varieties to plant must depend upon the outcomes of previous decisions. All others depend on negotiated access and use of land and labour, the timing and method of land preparation and soil fertility improvement, the build-up of weed populations, changes in soil fertility levels and existing food stores and seed stocks. Once completed, planting is followed by equally complex sets of choices over the timing and method of weeding (including labour negotiations and payment), thinning, transplanting, over-seeding, and finally, harvesting. The season is a process of sets of choices that require prioritisation before the next set of choices. In a risk-prone environment, each farmer's ability to create opportunities (or adapt) is challenged by resource constraints that are very individual in nature. The network maps reflect this ability. Chapter Six will build on the information in these network maps, incorporating them into statistical groups for different farmers with similar coping strategies, based on household 'capital assets'. The relationships between the endowments are also explored statistically in Chapter Six.

5.5 Conclusions

The analysis of the personal stories and local perceptions identified a complex narrative of agricultural decisions governed by rainfall variability, which reinforced the land managers' need to draw on their local knowledge and continually adapt practice and investment. Making choices and priorities within this context was a complex task. Planned performances were often played within a sequential set of performances, which themselves fed back to create new contexts.

The local ecological knowledge of change and spatial variability was used to domesticate micro-level complexity in the environment, creating a manipulated farming ecosystem which has been enriched by Djerma farmers and Fulani livestock keepers alike, and steered through various endogenous and exogenous processes of change. The farmers practised precision farming, targeting investment, minimising nutrient losses and maximising nutrient recycling to the best of their individual ability. Their local knowledge incorporated the spatial variability of soil fertility as a dynamic and ephemeral pattern and they determined this variability using indicators of soil quality characteristics, vegetation characteristics, and species and associations. Clearly the farmers understood the processes and relationships in the scientific intensification debate and the lack of the adoption of conservation techniques or added investment in the farm was not for a lack the knowledge of how to intensify sustainably. All the farmers experimented with risk-avoidance practices and exploited opportunities in the micro-variability on their farms, including the use of trees (for example, sandy soils are used in dry years but the relatively richer clay soils are used in wet years). These techniques include multiple planting dates, planting several seeds in each hole, mixing seed varieties and planting densities, intercropping associations and sequencing, and the use of different mulches to control wind erosion and improve soil fertility.

In addition to matching nutrient applications to variable soil fertility, investment had to be matched to equally variable household endowments and entitlements. Natural resource management was perceived by the farmers to be based on multiple capital assets. These included both natural and physical assets, such as the bioproductivity of their land, the rainfall and the distribution and size of the farm, and human, social and financial assets, such as the ability to mobilise labour, local markets, tenure arrangements, status, identity, wealth, cash and livestock. Choices through the agricultural season were grounded in farmers' perceptions of these assets and their perceived constraints and opportunities influenced the resulting prioritisation.

'Mapping' of visual geographies of investment and land allocation through the agricultural season represented households' approaches to coping and identified which assets were perceived to be important in providing opportunity or constraint. The 'maps' identified the multidimensional aspect to learning (by inherited, collective and individual experience) and reflected the social construction of natural resources out of the knowledge and capabilities of the local people. The maps illustrate individual's perception of entitlements to resources. Local science reveals a reading of environment that is often rooted in the concrete, in the history of local people and their identity, in the landscape, and in daily obligations. Access to this 'different way of knowing', rooted in common knowledge, was aided by local collaboration and by careful familiarisation during time spent in the village, but the picture presented here cannot claim to be complete. However, the text available suggests that the experience of farmers in Fandou Béri can be best described as a flux of analytic laws, ideas and concepts.

When this approach is considered in a wider perspective, controversies over the culpability for Sahelian degradation of natural resources merge into the longer story of how communities like Fandou Béri, using their own labour, have managed natural capital and ensured livelihoods by the maintenance and manipulation of natural diversity. This positive picture of livelihood adaptation clashes with contemporary evaluations of Sahelian farmers either as environmental spendthrifts, or as being caught up in forces they cannot control.

Nevertheless, a pattern of expansion and intensification, shortening fallow rotations yet low investment, evidence for high rates of soil erosion and a cash-poor local economy indicate a struggling farming system. While not all the scientific evidence is convincing, soil fertility was considered by farmers to be the most important part of their natural capital, and one which they could directly influence. The farmers perceived soil fertility to be decreasing on certain fields, especially low-fertility soils around village, and they believed that they were not all able to produce sufficient organic fertiliser to balance nutrient outputs. Few, if any, were able to buy mineral fertilisers to complement organic inputs. Low and unpredictable millet prices provide little incentive for most of them to invest in the agricultural sector of their livelihoods. However, investment in livestock was popular and seen as a means of developing integrated soil management. Long-term fallow rotation was seen as by farmers to be untenable.

The analysis of the perceptions of natural resource management showed that integrated and sustainable practices are a complex issue, which are not dependent on nutrient balances alone. From the evidence in the case studies, it may be unrealistic to regard fallow rotation systems, for example, as primarily adaptations to differences in natural conditions when they also depend on judgement and socio-economic variables. This chapter has helped to focus attention on farmers' perceptions of their capabilities (and limitations) in the production system and shown that value is placed on maintaining choice to maximise flexibility and minimise risk.

The diversity reflected in this chapter is analysed further in the next chapter, to identify more clearly the determinants of land allocation and soil fertility investment and the differences and similarities between households. The farmers' perceptions of strategy differentiation and constraints, presented in this chapter, are compared with the strength of influence of each set of capital assets to understand patterns in investment and access.

6
Diversity in land management practice

Households are not equally endowed with labour, natural resources, capital or management capabilities. Chapter Five revealed how farmers' perception of this diversity affected their process of choice and prioritisation for natural resource management. This chapter tests these perceptions by investigating differences and similarities in household data and identifying patterns of farm investment and land allocation. While exogenous forces also play an important role in the pattern of differentiation, with links between poverty and food insecurity, the 'moral economy', wealth and the wider political-economic changes (Watts, 1984), an empirical examination at the local-level remains crucial.

First, an analysis using statistical techniques is used to explore the underlying structure and patterns in the household data in a large database. The data are organised round various household endowments, within a Sustainable Rural Livelihoods framework of 'capital assets'. Building on the results of these analyses, the study asks whether the key determinants of Djerma land allocation (to cultivation or to fallow) and the key constraints to soil fertility investment can be identified using the statistics at farm-, field- and plot-scale. The key variables of soil quality, labour availability, wealth and the size and distribution of the farm are examined. In addition, the issue of intentional and unintentional fallow is introduced. Then to explore spatial representations of diversity, a GIS map is used to identify geographical patterns of farm fragmentation, zones of land management practice and the relationship between soil type and resource productivity. These patterns are discussed in terms of the social meanings that are attached to space and of farmers' perceptions of soil fertility in relation to agro-scientific soil maps.

Second, the study acknowledges the problems in using a statistical approach to understand why there is such diversity in farmers' investment and land allocation. This part of the study attempts a more complete answer by discussing the differentiated strategies in land use management with selected case studies containing detailed fieldwork. These examples aim to illustrate historical and social processes, as well as economic ones. Each example provides evidence of the dynamic, individual process of choice and prioritisation involved in land management practice and the capacity to cope. The section concludes with schematic models to represent the results of the analyses and the farmers' perceptions of influences on farm investment and land allocation, and introduces the problems in seeking simple relationships between poverty and land use.

6.1 Organising household endowments

As illustrated in the presentation of intra-household endowments in Chapter Five, a high degree of complexity exists within and between the sample households. Quantitative information on this complexity was structured into a database to which statistical techniques could be applied. A 'Sustainable Livelihoods' framework was used such that the data were organised into themes of 'capital assets', as described in section 3.3. These themes were identified as 'natural', 'social', 'physical', 'economic and 'human' resource 'assets' (table 6.1).

It is acknowledged that the quantitative data collected represent only a snapshot of the twenty households' livelihood strategies, but nevertheless, they are complementary to the qualitative information. The quantitative data provide a picture of the resource assets that were available to the study households at the beginning of the 1998 rainy season, the time when farmers were beginning to make choices about land allocation, labour investment and soil fertility management for that agricultural year. It was a time when many were returning from migrant work and deciding on the use of the household assets for the season.

The information in table 6.1 was collected for all fields on the farms of the sample households, which at the beginning of 1998 totalled 58 fields. The household data were collected during fieldwork and additionally some variables were supplied by the SERIDA database (the variables were selected because the data could be quantified).

Table 6.1: Quantitative data organised into household 'resource asset' themes

Theme from the Sustainable Livelihoods framework	Quantitative data for assets at start of 1998 rainy season*
NATURAL ASSETS	• Average productivity (kg/ha/yr for 1996-97) • 1997 millet harvest (*boko* and kg) • Fallow age (years) • Farmer classified soil fertility
SOCIAL ASSETS	• Number of fields on loan • Number of fields borrowed • Manure exchange • Number of men on *exode* 1997-98 dry-season (off-farm activities) • Petty trade involvement (off-farm activities)
PHYSICAL ASSETS	• Distance to field (km) • Area of field (ha) • Total number of fields cultivated in 1998
ECONOMIC ASSETS	• Number of paid labourers • Number of fields owned • Total number of livestock in household care (Tropical Livestock Units) • Number of cattle owned • Number of small ruminants owned • Number of donkeys owned • % field actively manured (transported manure) • Household income for 1997 (F CFA) • Household expenditure in 1997 (F CFA) • Farmer estimated household millet needs (boko per year)
HUMAN ASSETS	• Total household size • Female household size • Male household size • Family labour available (weighted to labour input) • % burning practised on field • % mulching practised on field • % field fallow • Number of household bushplots • Millet seed type used

* *For summary data and sample questionnaires see Appendix 1 and 2.*

6.2 Patterns of diversity

6.2.1 Underlying structure

Multivariate principal components analysis was used to examine the underlying structure of the data and to identify statistically important variation. The technique creates a set of factor scores and eigenvectors (E), shown in tables 6.2 and 6.3. These values represent the weighting of each variable point in multidimensional space (or the total variation of the data). The values are direct indications of the importance of that component in explaining the total variation in the data set for the 58 fields. Those factors with higher scores can be used to explain the underlying structure in the data.

Analysis of the data for all farmers in the study, which includes both Djerma and Fulani, showed that 30% of the variation is explained by the first two principal components. This significant explanation of the data structure is presented in table 6.2. The table shows the strength of household access to male family labour (male household size and the weighted labour input) on factor score 1 (PC1). The strength of access to organic inputs (or the number of small ruminants owned by the household and total livestock (TWU) in the household's care) is shown by factor score 2 (PC2).

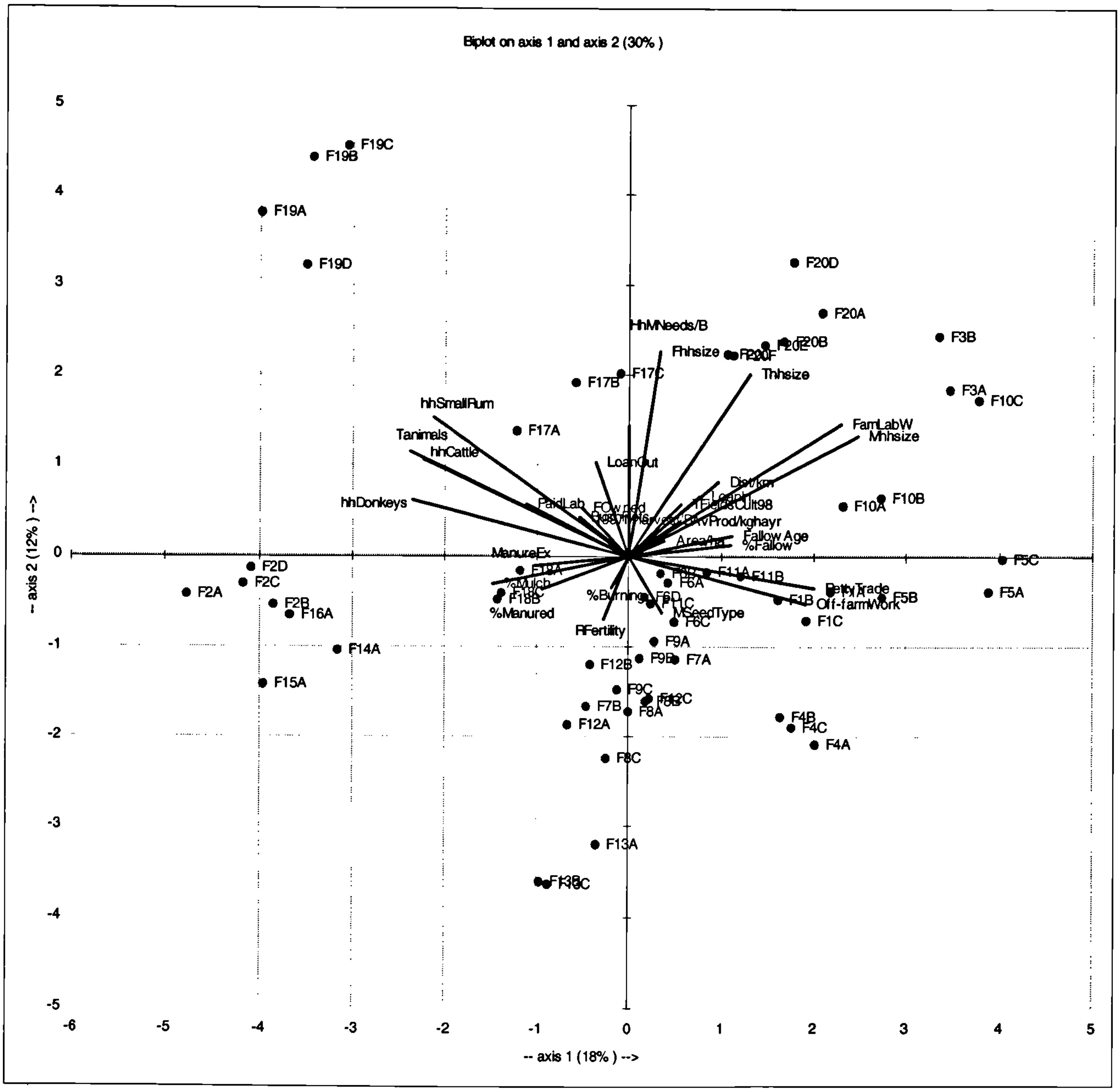
Using this information, it is possible to return to the hypothesis that land type and socio-economic group is a major differentiating factor in the household data (see section 1.3). The statistics suggest that the size of a household's livestock holding, which is an indicator of accessible household wealth, plays a significant role in the variation of the sample data. It is therefore argued that economic differentiation is important in structuring the diversity. Besides the high factor scores of labour and livestock availability, the table can be used to infer that a number of other variables, with relatively high scores, also order the data. Most of these are social and human assets; land type plays a less statistically significant role.

Table 6.2: PCA output for 20 households

Variable	PC1	PC2
Eigenvalue	5.1380	3.5885
Proportion	0.177	0.124
Cumulative	0.177	**0.301**
Average Productivity (kg/ha/yr)	0.074	-0.075
1997 Millet Harvest (kg)	-0.069	-0.079
Fallow Age (yrs)	0.153	-0.044
Farmer Ranked Fertility	-0.037	0.137
Number of fields loaned out	-0.051	-0.203
Number of fields borrowed	0.105	-0.130
Manure Exchange	-0.141	0.022
Off-farm activities	0.263	0.105
Petty Trading activities	0.275	0.070
Area of field (ha)	0.054	-0.032
Distance to field from homestead(km)	0.134	-0.161
Total number of fields cultivated 1998	0.078	-0.113
Number of labourers hired	-0.153	-0.112
Number of fields owned	-0.071	-0.103
Total number of livestock cared for by household	-0.128	**-0.226**
Number of household cattle owned	-0.308	-0.210
Number of small ruminants owned	-0.293	**-0.301**
Number of donkeys owned	-0.304	-0.121
% field fertilised with transported manure	-0.131	0.073
Household yearly millet needs (boko)	-0.000	-0.285
Total household size	0.178	-0.198
Female household size	0.045	-0.047
Male household size	**0.340**	-0.214
Family labour (Weighted)	**0.314**	-0.219
% field burning practised	-0.026	0.069
% field mulching practised	-0.204	0.062
% field left in fallow	0.151	-0.024
Number of household bush plots	-0.074	-0.085
Millet seed cultivar	0.049	0.124

The multivariate output from table 6.2 is easier to interpret in a graphical representation, as shown in figure 6.1.

Figure 6.1: PCA diagram showing variables structuring household data



The graph clearly differentiates the household data. The household fields are grouped against components 1 and 2, where axis 1 can be seen to represent family labour and axis 2 the size of the household livestock holding. The lengths of the biplots show the strength of each variable against axis 1 and 2. The location of a case (i.e. household field) in relation to each biplot (i.e. variable) indicates the strength of that variable in explaining the underlying data. The groups of cases can be said to show the differentiation and also the similarities between households.

Figure 6.1 reveals that there are distinct statistical differences between the Fulani farms and the Djerma farms. The Fulani farms are clustered into a group, together with the farm of the village chief, at the high point of the livestock biplot. Apart from the chief's household there is only one other Djerma farm indicated as having an exceptionally high livestock holding (top left). The rest of the Djerma farms are clustered to the right of the diagram. These are differentiated along a biplot of family labour availability, with the cluster at the top represented by high availability and the cluster at the bottom by low availability. In addition, the farms to the right of the diagram are influenced by off-farm activities.

Cluster analysis (figure 6.2) confirms the underlying pattern in the data and helps to identify the groups of cases with statistical similarity. The fields, along the bottom of the diagram, are separated into seven groups that correspond to the seven groups seen in figure 6.3.

Figure 6.2: Cluster analysis grouping of cases

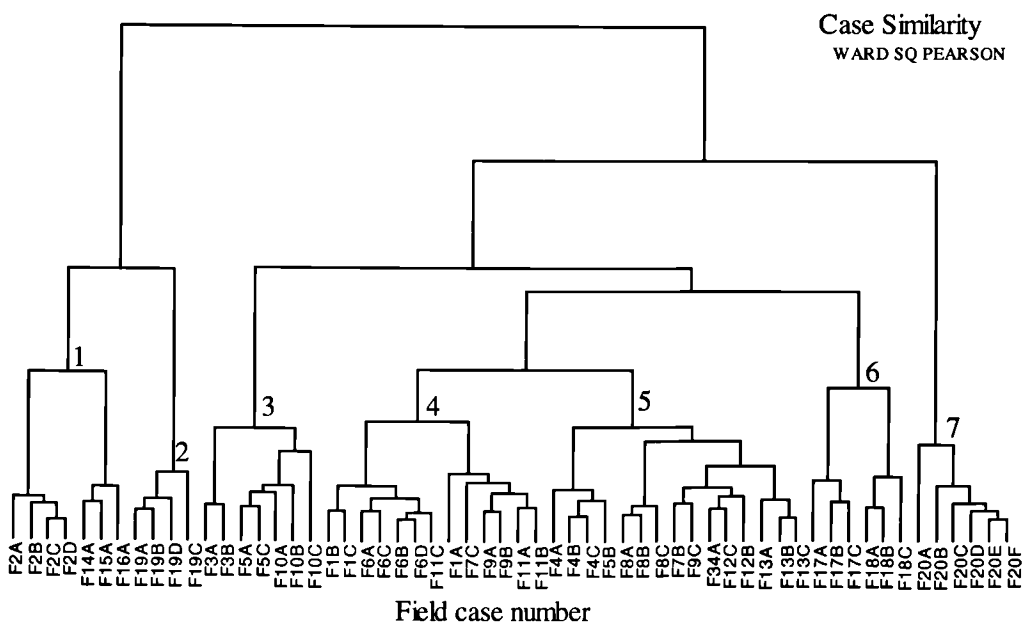
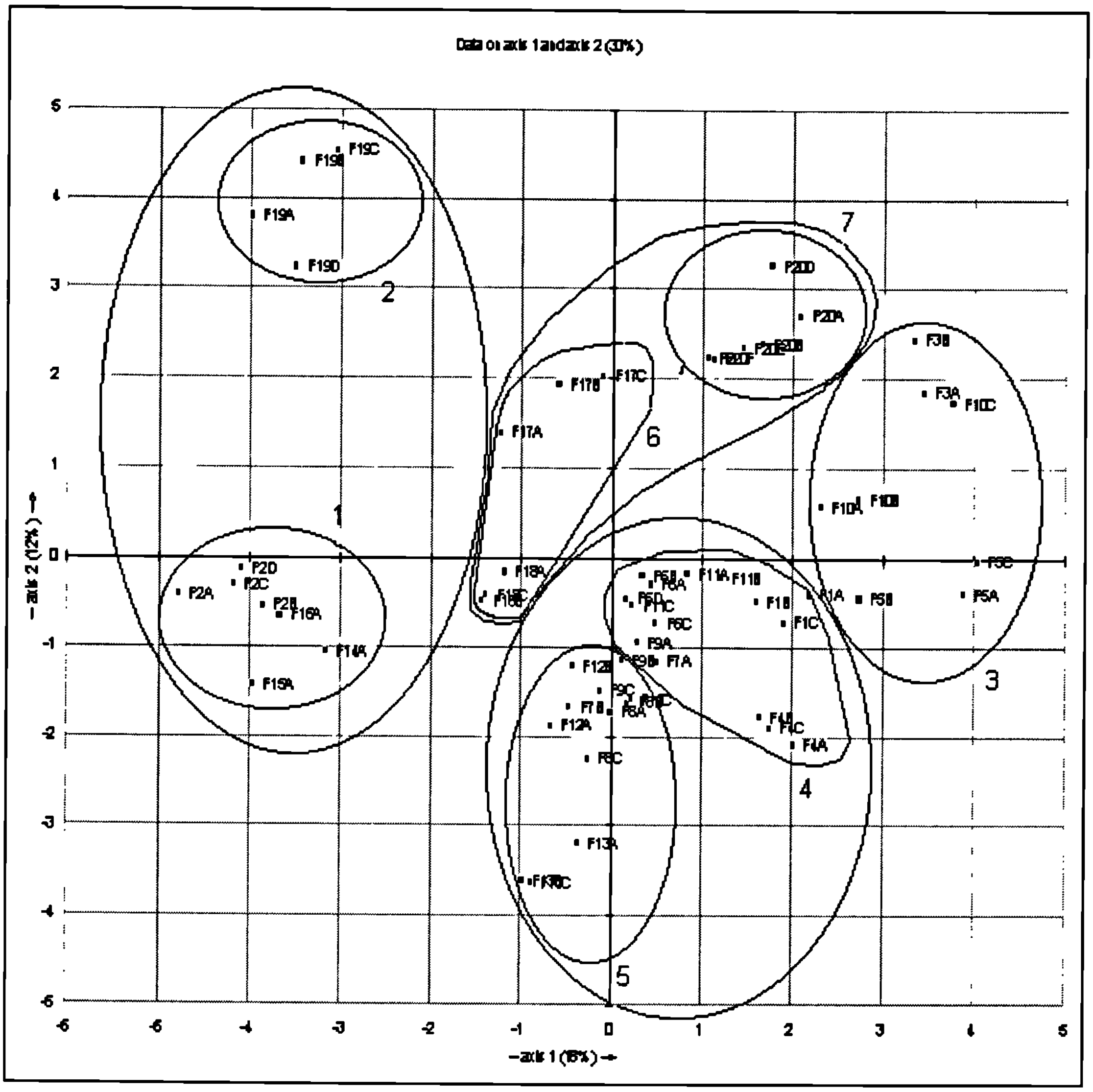
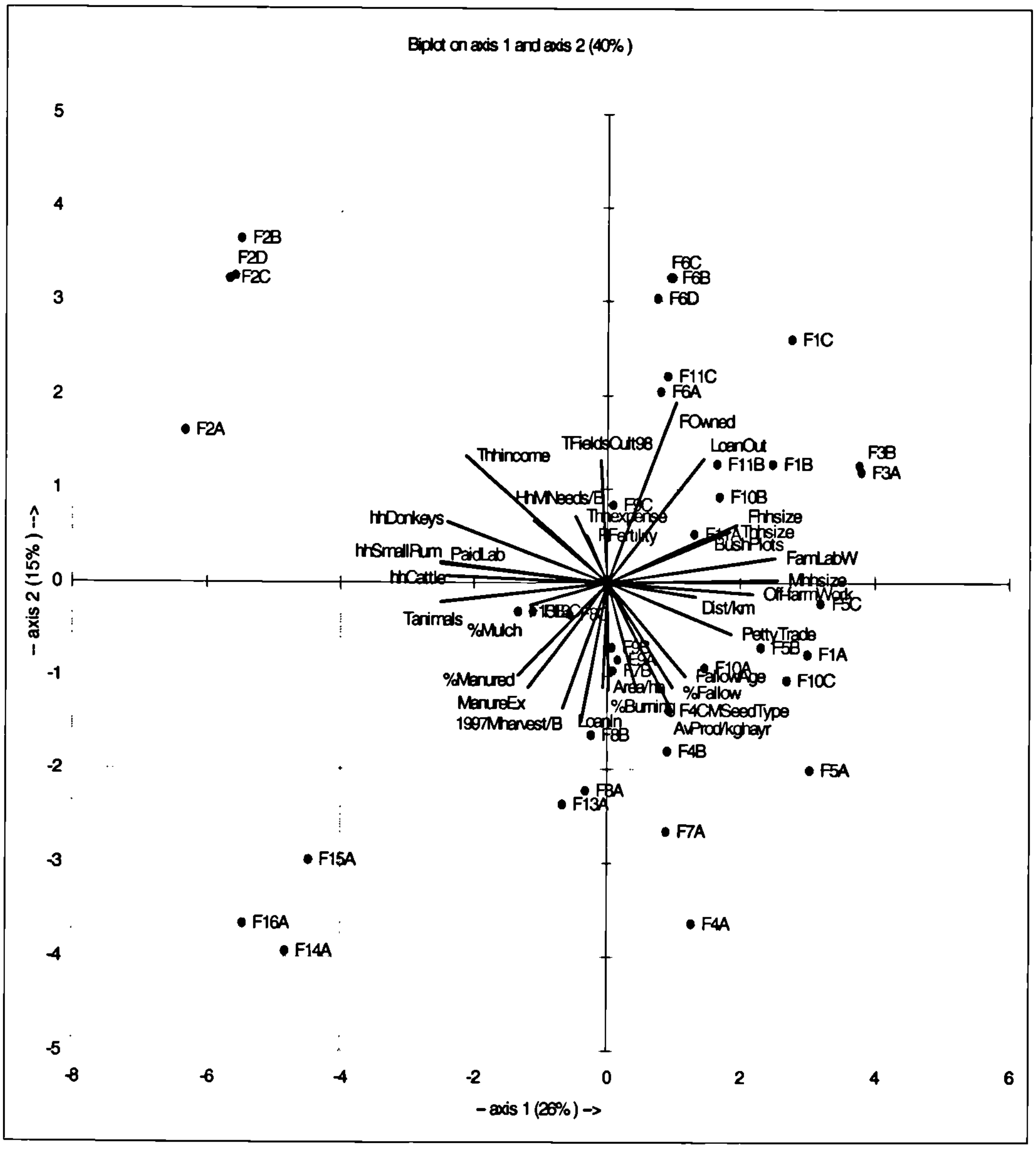


Figure 6.3: PCA diagram without biplots showing seven case groups



If household income is included in the analysis, the number of cases are reduced but the differentiation between Fulani and Djerma farms is still distinct, and the axes remain the same (figure 6.4). Although 40% of the variation is explained, this is due to the correlation between livestock holding and income, and therefore does not increase the statistical differentiation.

Figure 6.4: PCA diagram showing variables, including income, structuring household data



The significant differentiation between the Djerma and Fulani cases suggests that the data structure for Djerma farms should be explored separately. Table 6.3 gives the PCA output for analysis of the Djerma farms alone, and shows the strength of livestock holdings and access to organic inputs (PC1) and the strength of family labour availability (PC2) in explaining the underlying data structure. The cumulative eigenvalue shows that factors 1 and 2 can explain 31% of the variation.

Table 6.3: PCA output for Djerma households

Eigenvalue 5.1312 3.8618		
Proportion 0.177 0.133		
Cumulative 0.177 **0.310**		
Variable	PC1	PC2
Average Productivity (kg/ha/yr)	0.088	-0.140
1997 Millet Harvest (kg)	0.021	-0.173
Fallow Age (yrs)	0.155	-0.106
Farmer Ranked Fertility	-0.019	0.144
Number of fields loaned out	-0.138	-0.151
Number of fields borrowed	0.144	-0.156
Manure Exchange	-0.068	-0.004
Off-farm activities	0.255	0.048
Petty Trading activities	0.267	0.002
Area of field (ha)	0.136	-0.116
Distance to field from homestead(km)	0.086	-0.191
Total number of fields cultivated 1998	0.014	-0.064
Number of labourers hired	-0.153	-0.065
Number of fields owned	-0.207	-0.012
Total number of livestock cared for by household	**-0.346**	-0.231
Number of household cattle owned	-0.319	-0.192
Number of small ruminants owned	**-0.338**	-0.251
Number of donkeys owned	**-0.338**	-0.079
% field fertilised with transported manure	-0.020	0.041
Household yearly millet needs (boko)	-0.003	-0.261
Total household size	0.087	**-0.405**
Female household size	-0.046	**-0.431**
Male household size	0.284	**-0.308**
Family labour (Weighted)	0.257	**-0.325**
% field burning practised	-0.013	0.067
% field mulching practised	-0.195	0.091
% field left in fallow	0.164	-0.084
Number of household bush plots	-0.138	-0.030
Millet seed cultivar	0.091	0.191

When this multivariate output is represented graphically (figures 6.5 and 6.6), the clusters of farms can be observed along axis 1 (size and composition of livestock holding) and 2 (family labour size and demography) and in relation to the biplots. Cluster analysis can be used to impose statistically significant groupings, as shown in figure 6.6.

The cluster in the top-left section of the diagram in figure 6.6 represents cases where high labour availability is significant to the data structure. The cluster in the top-right section of the diagram represents cases where the data are organised by high availability of both family labour and livestock. The majority of cases are grouped in the central section of the diagram, differentiated by the axis variables. For example, cases numbered 13A to 13C are ordered by low family labour (from the axis 2) although the fields are fertile (from the fertility biplot). For cases 1, 4, 5 and 7, low resources order the data, with fallow practice and off-farm activities both playing a significant role. The biplots indicate which other variables are important to each case, such as the importance of the number of household donkeys for transporting manure and the value of paid labour. The significance of female household size on the data should be noted, indicated by the length of the biplot 'Fhhsize'. The number of women in the household plays an important role in periods of peak labour demand, such as planting, and raises household family labour availability for families unable to hire extra male labourers.

Figure 6.5: PCA diagram for Djerma households showing variables structuring data

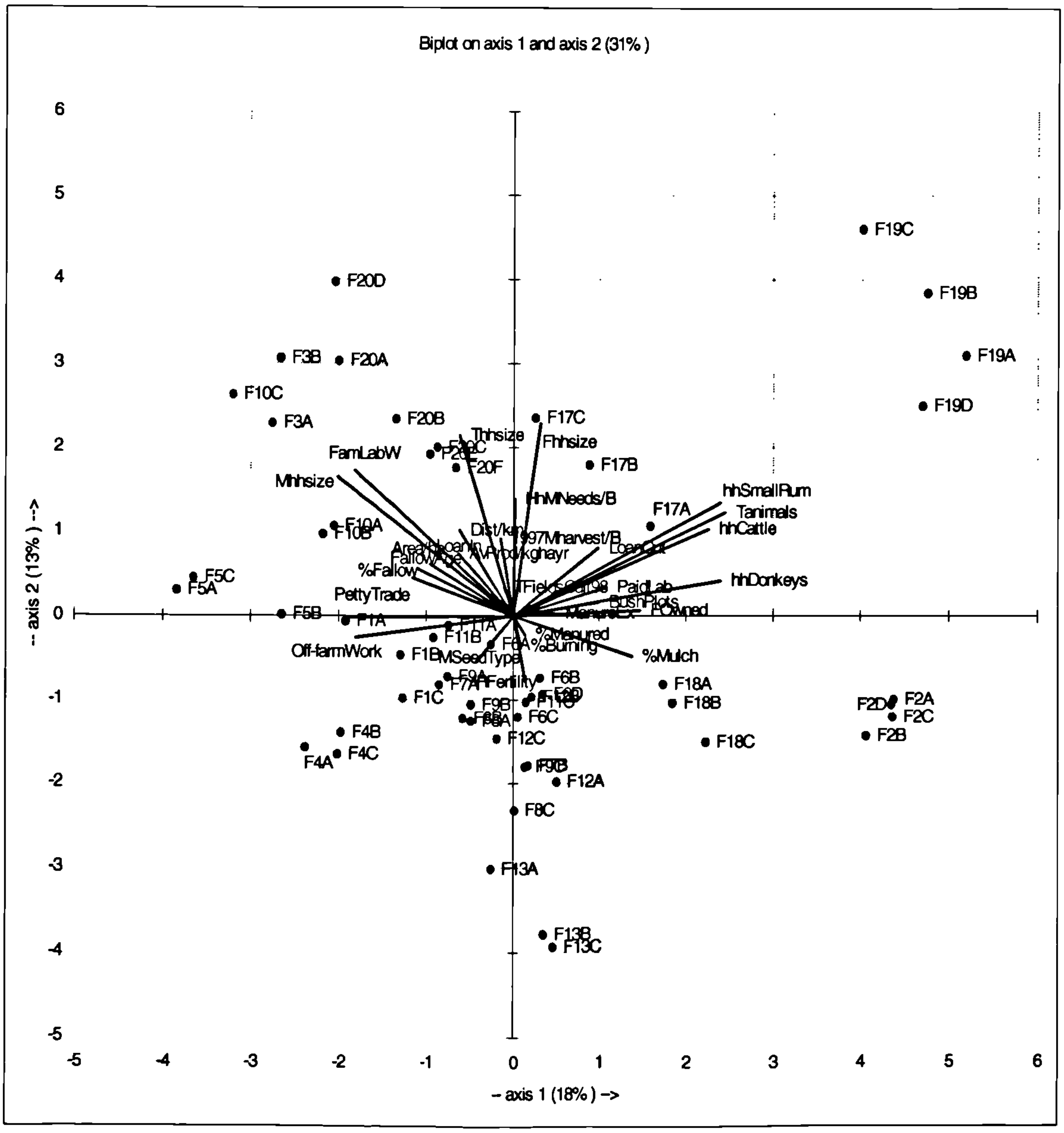
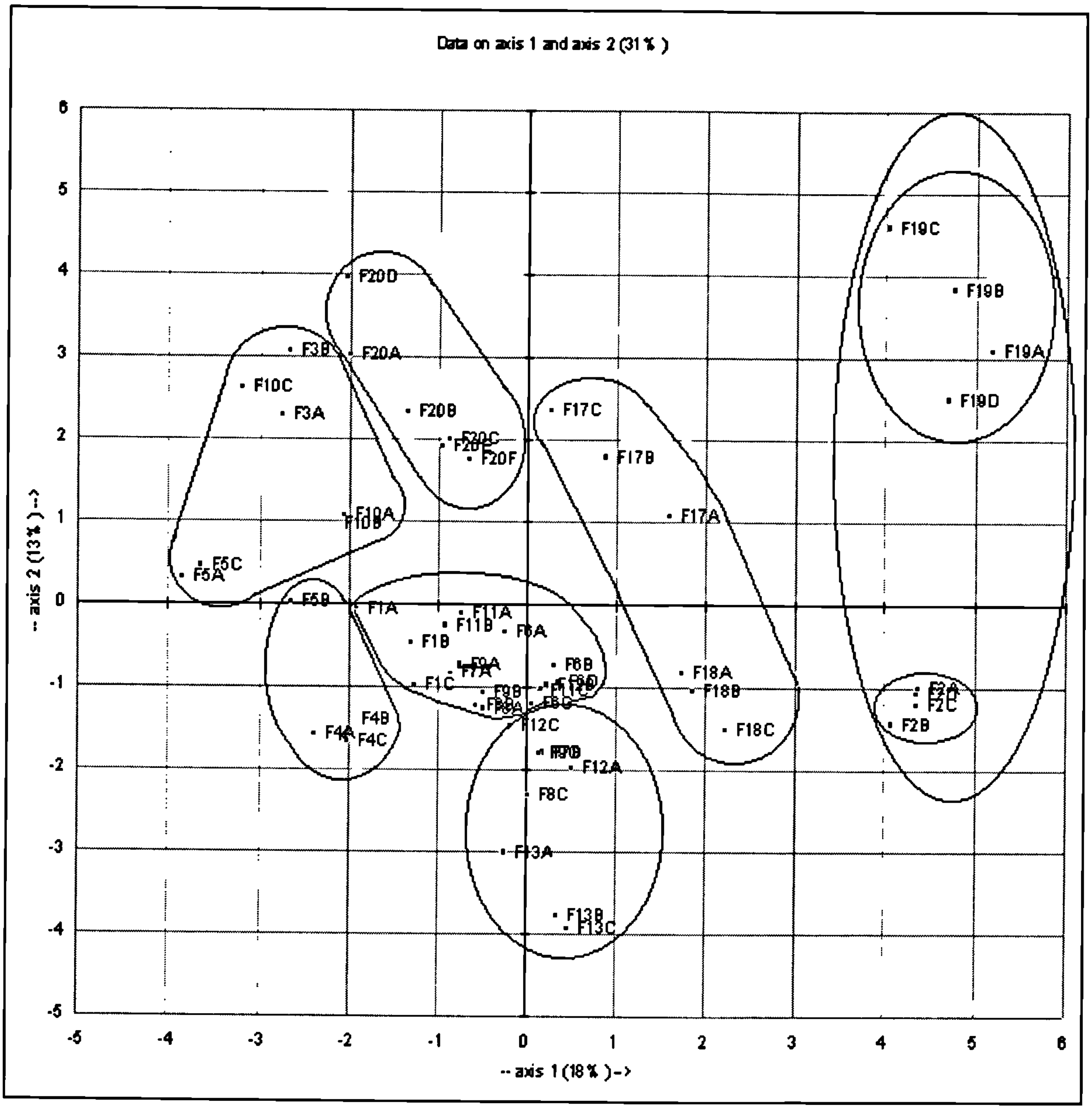


Figure 6.6: PCA diagram without biplots showing Djerma case groups



6.2.1.1 Summary

In summary, the multivariate analysis identified statistically important variation in the household data. It shows the significant influence of socio-economic variables in differentiating these data. The size of the family's labour force and livestock herd, in particular the number of small-stock, were the most significant variables, which explained 30% of the household variation for all the sample households and 31% for Djerma households. Furthermore, cluster analysis identified statistically significant groups of households, the differentiation between households that had low and sufficient access to resources.

6.2.2 Determinants of Djerma land allocation – cultivation or fallow?

The patterns of variations identified in sections 6.2.1 were explored further using multiple regression and correspondence analysis to seek to identify the most important determinants of land allocation (specifically land put into cultivation or into fallow). Although the relationships are weak, the most relevant factors are addressed separately in the following sections. The study had asked if soil fertility was the most significant factor driving this decision but the previous sections have shown land allocation to be the result of a number of interacting variables. This was reaffirmed by the analysis presented in this section. Relationships between land use allocation and soil quality, labour availability, wealth-related indicators (such as livestock holding) and the size of the farm and distribution of its fields were explored. The weakness in the statistical analysis indicates the diversity within the data, as discussed later.

6.2.2.1 Relationships between soil quality and land-use allocation

As already discussed, the farmers' conceptions of soil quality incorporate the history of land use, including past yield, the length of time in fallow, past crops grown, inorganic and organic inputs and other activities. The quality of the soil is summarised in the local soil name. It indicates fertility, structure, topography, erosion and biological processes. Because of this, the local names were used in this analysis. Figure 6.7 shows the distinct relationship between farmer-graded soil quality and the percentage of each field in short-fallow during the 1998 season.

The highest percentage of fallow was found on fields with soils said to be of low fertility. The fields with these high proportions of fallow were predominately *tassi* soils in the 'village-field' zone. Less than 10% of these fallow areas had *botogo* soils, or were in the 'out-field' zone. The pattern in figure 6.7 is undoubtedly influenced by the rainfall regime in 1998. This was a 'good' rainy season, in which the percentage of fallow on high quality soils was low. These soils were considered by the farmers to be most productive under better rainfall regimes but not under poor rainfall. To some extent the diagram also reflects the proportional area of each soil type. Most soils in the territory are *tassi* (approximately 45% according to the farmers). In the poor rain year of 1997, the percentage of fallow was higher than in 1998 for *tassi* and notably also for *botogo* and *gangani* (figure 6.8), this pattern being most commonly attributed by farmers to abandonment of seeded areas due to drought.

Figure 6.7: The relationship between farmer-graded soil quality and the percentage of field in fallow in 1998

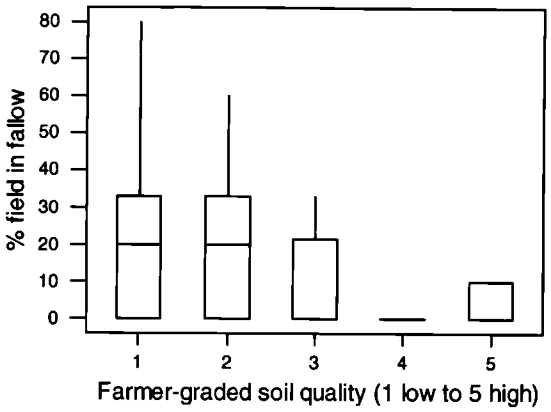
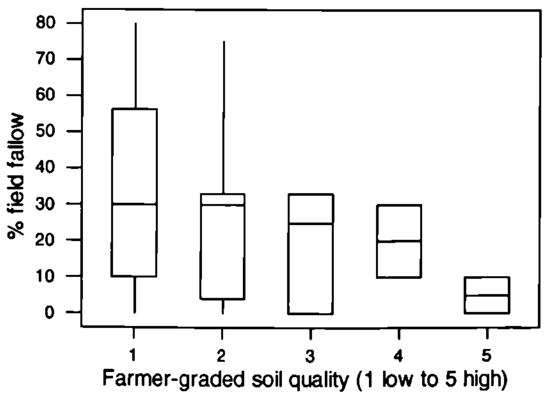
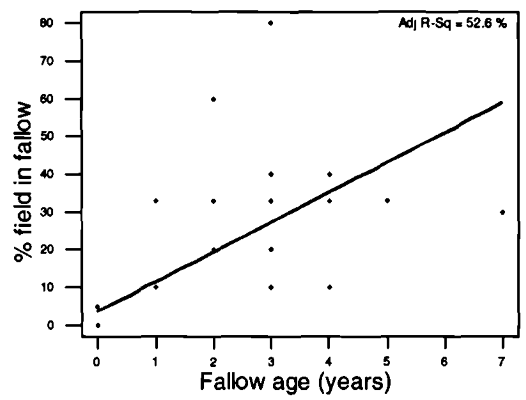


Figure 6.8: The relationship between farmer-graded soil quality and the percentage of field in fallow in 1997



Thus the interaction of soil quality with rainfall is an important factor in land use allocation. A further indication of this relationship was the occurrence of older fallow plots on low quality soils (figure 6.9). Higher quality soils were not left in fallow for the same length of time.

Figure 6.9: The relationship between fallow age and the area of the field left in fallow



The quality of the soil was an important determinant at plot scale, influencing what practices were necessary, what areas of the farm were cultivated and with which type of crop. Figures 6.10 and 6.11 show the relationship between soil quality and the extent of mulching, and the relationship between this practice and the percentage of fallow.

Figure 6.10: The relationship between farmer-graded soil quality and the percentage of the field mulched

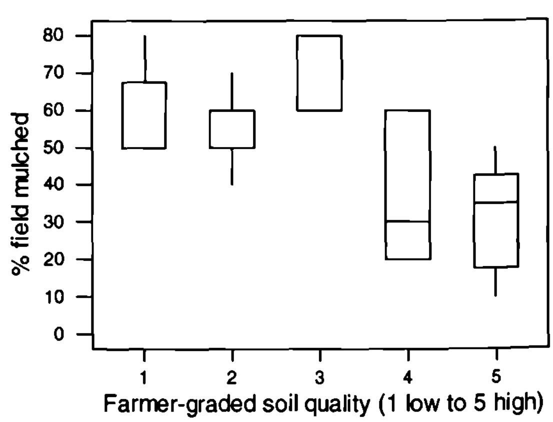
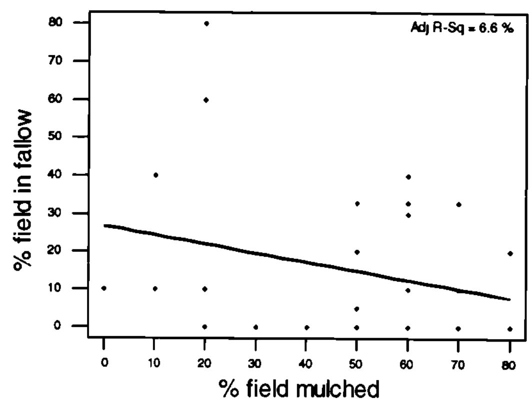


Figure 6.11: The relationship between the percentage of the field mulched and the percentage left in fallow



Fields with *gangani* or *korobanda-tassi* soils had the highest percentage of mulching. Farmers claimed that there was less reason to put land that has been mulched into fallow.

6.2.2.2 Relationships between labour availability and land use allocation

The capacity of a farmer to mobilise labour (and maintain a high labour-to-farm area ratio during the agricultural season) is influential in the decision to cultivate. Fragmented farms require higher labour investments and therefore large families would be better placed to cultivate a larger percentage of their farm than smaller families. Figure 6.12 shows that families with a higher weighted family labour force were farming more fragmented farms. Although this does not in itself prove a causal relationship, it does imply that the relationship between labour force and location will be a key factor when making farm management decisions, with close fields preferentially cultivated.

Figure 6.12: The relationship between family labour and the number of fields cultivated in 1998

The size of the household and the household demography influenced the extent to which the household members were able to mediate access to additional resources that could be used in farm investment and thus affect land allocation. For example, households with more women had access to more manure from small ruminants (being reared for sale predominately by the women) (figure 6.13).

Households with more men allowed some members to undertake off-farm activities, without presenting the household with severe labour shortages at the start of the season (figure 6.14). These households were better placed to invest in the farm if they chose, or to invest in livestock, presenting the household with methods of soil improvement other than labour-intensive practices such as mulching. Figure 6.15 suggests that the larger the male household size, the lower the amount of mulching that was practised on the farm. Furthermore, although there is no statistically significant relationship between income and migration, households that had members which left the village for work during the dry season had an average annual income of 150 000 – 250 000 f CFA (the mean for the sample households was 123 077 f CFA).

Figure 6.13: The relationship between the number of women in the household and the number of small ruminants owned by the household

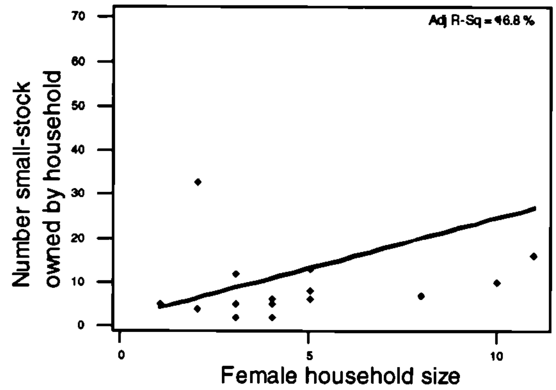


Figure 6.14: The relationship between the number of males in the household and the number of men who undertake off-activities during the dry season

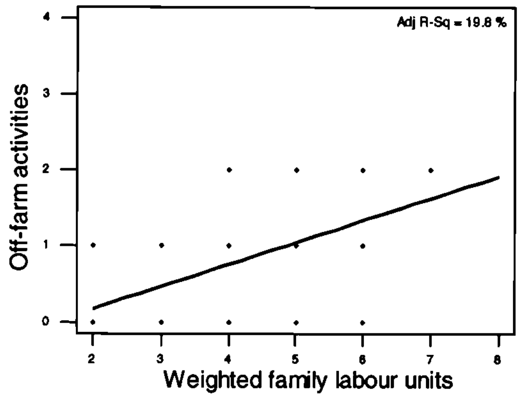
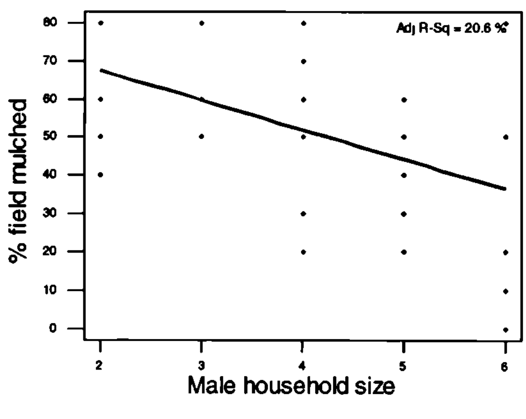


Figure 6.15: The relationship between the number of males in the household and the percentage of the farm mulched



6.2.2.3 Relationships between wealth indicators and land use allocation

Figure 6.16 and table 6.4 suggest that wealthier Djerma households had less of the farm left in fallow compared to households with lower incomes or fewer livestock. As figure 6.17 shows, income was correlated to tropical livestock units (TLU). The statistics suggest that these wealthier households had fewer constraints to farm management, were less dependent on fallow to maintain fertility and were able to arrange access to manure for soil fertility improvement.

Table 6.4: Relationship between livestock and number of fields under fallow

Number of livestock* in household	Number of households with fallowed fields	% Total number of fallowed fields
0	0	0
1-10	8	47
11-20	3	18
21-30	3	18
>30	3	18
Total	17	100

**excluding fowl*

Figure 6.16: The relationship between household average annual income and the percentage of the farm left in fallow

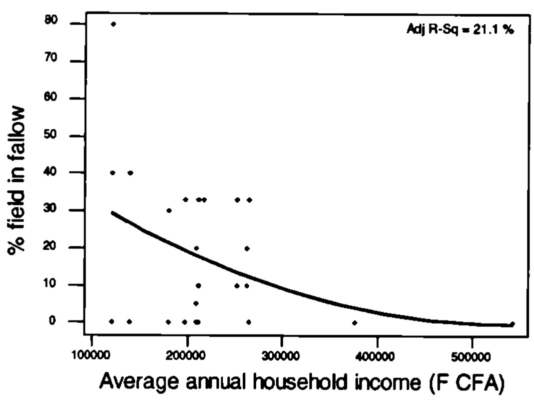
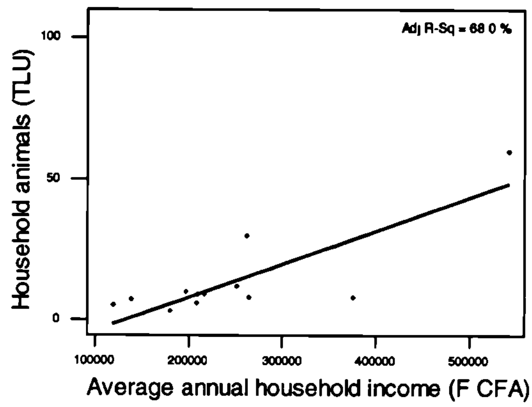
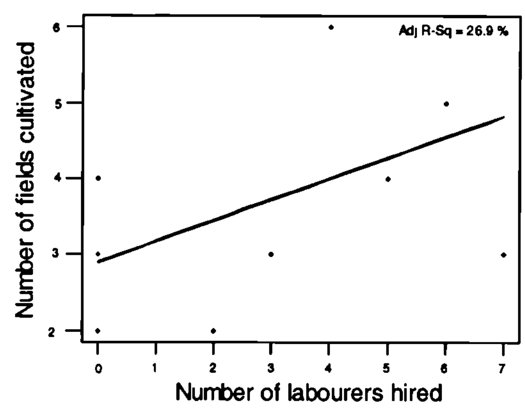


Figure 6.17: The relationship between household average annual income and the number of cattle owned



The number of paid labourers hired by households was correlated to the household income. The ability to arrange extra labour during peak demand increased the probability that a larger percentage of the fragmented farm would be under cultivation (figure 6.18).

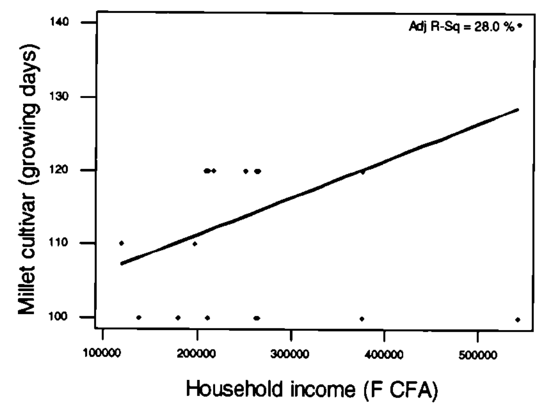
Figure 6.18: The relationship between the number of labourers hired by a household during the 1998 season (before harvest) and the number of fields cultivated



However, the pattern was complicated by the additional choices that wealthier households were able to make. These reinforced income growth because the farmers were able to buy extra seed and thus to cultivate more land. This is not to suggest that wealthy households never left land in fallow, but that which they did leave could be attributed to temporary annual constraints, most significantly pest attack, flood damage or drought. The concept of 'intentional' and 'unintentional' fallow practices is discussed further in section 6.2.2.5.

Finally, there is evidence that poor households, which were most vulnerable to food shortages, were using short-maturing millet cultivars because they were able to harvest the crop earlier (figure 6.19). Wealthier households grew these cultivars on the closest fields, but were not interested in growing them on all their fields because they had the capacity to purchase food at the height of the hungry season.

Figure 6.19: The relationship between millet cultivar and the household's income



6.2.2.4 Relationships between the size and distribution of the farm and land-use allocation

The size and distribution of the farm had a significant impact on land use allocation. 'Distribution' here refers to the fragmentation and location of fields. Figure 6.20 shows that field size increases with distance from the village centre. Farmers argued that there was little space for fallow on the small 'in-fields' near to the village. This suggests that the increased fragmentation of fields in the 'village field' zone has reduced the use of fallow. This is an important consideration, given that the larger fields have a higher productivity (figure 6.21). As field size is correlated to distance (figure 6.20), then it can be deduced that smaller fields close to the village were not as productive as out-fields, although this was also partly a function of the low quality of the soils in the immediately area around the village. Analyses of geographical patterns are investigated further in section 6.2.4.

Figure 6.20: The relationship between distance from village centre and area of fields

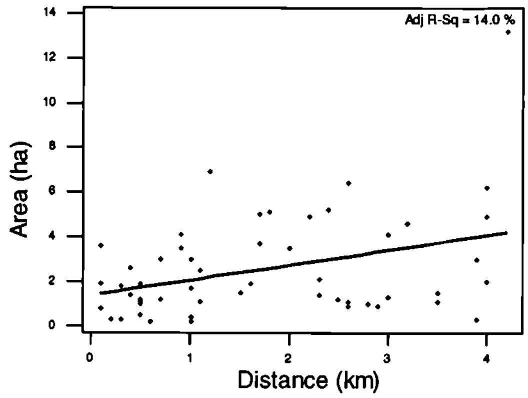
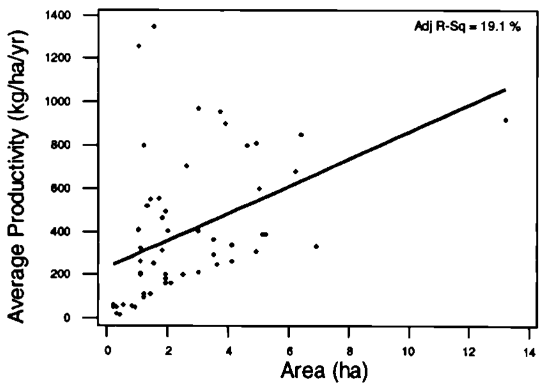
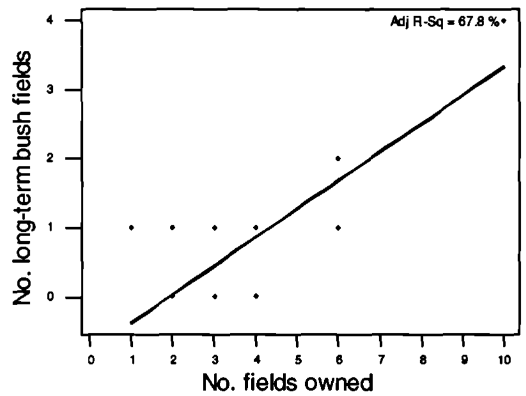


Figure 6.21: The relationship between field area and average productivity (1996-97)



The farmers argued that they tried to use labour in the most efficient way. However, as fragmentation of the farm is common, efficient labour management is often difficult. Hence, a weak statistical relationship exits between total farm area and the percentage area under fallow but not between field area and the percentage area under fallow. When additional land is considered, such as long-term uncultivated bush-fields beyond the village-fields, a more comprehensible pattern emerges. As figure 6.22 shows, larger farms had a higher number of fields left in permanent fallow and consequently the farmers of these farms managed the available land more extensively. These fields in permanent fallow were referred to as 'bush-fields'.

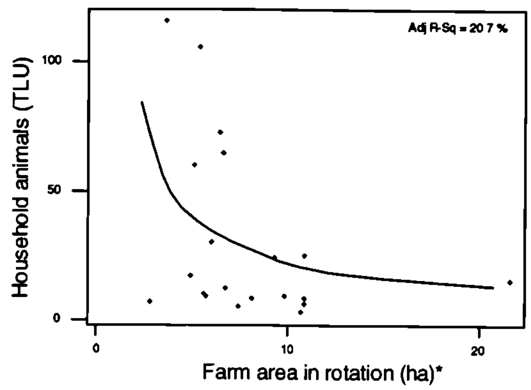
Figure 6.22: The relationship between the number of fields owned and the number of bush-fields



It is clear that the claim by farmers that they were afraid to leave fields in fallow for long, in case they were required by another family under the new tenure laws, was only true for those fields close to village and not for the out-fields where land was less desirable. Farmers with many fields also argued that to leave a large part of each field in rest would invite conflict. To overcome the problem, farmers with more fields than they were able to cultivate often lent them to neighbours in return for labour or a percentage of the harvest from the field.

The statistics show that smaller farms and smaller fields were managed more intensively. It would seem that a small farm does not always mean a low-income household, as the status of the household head within the village community was considered an equally important determinant of income. The higher number of livestock owned on these smaller farms indicates this (figure 6.23).

Figure 6.23: The relationship between the farm area in rotation in 1998 and the number of livestock owned by Djerma



*(*farm area excludes bush-fields and fields loaned out/ TLU=tropical livestock units)*

6.2.2.5 Intentional and unintentional fallow

The analyses of the patterns of diversity in land use has indicated that not all the land left in fallow was the result of intentional management. The farmers in Fandou Béri made decisions about land use at the start of the season, but not all were then able to hold to those decisions as the rainy season progressed, and as they encountered unforeseen constraints. In these cases the land was left in fallow unintentionally.

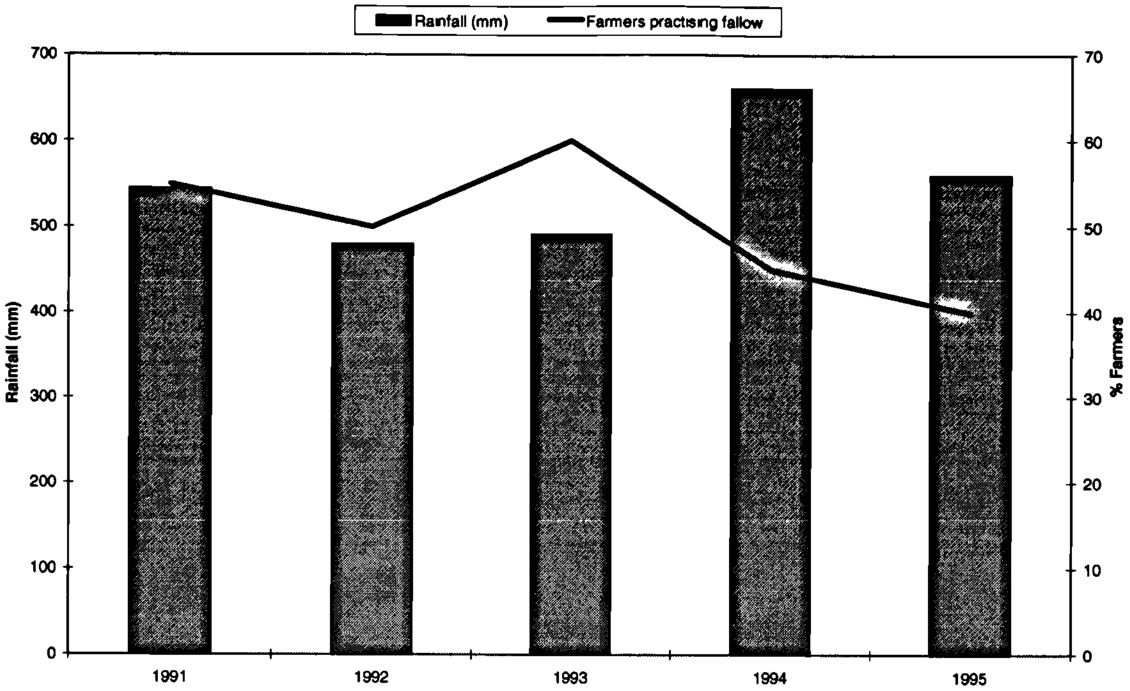
According to the farmers' responses, 85% claimed to be using some intentional short-term fallow rotation on their farm. However, intentional fallow was disproportionately found on *tassi* village-fields (75%), and only 10% found on other soil types. Some 15% of the farmers claimed to have intentionally left land in fallow at the start of the 1998 rainy season, while all farmers had some patches of unintentional fallow on their farm towards the end of the season. There were a number of reasons for this unintentional short-term fallow.

The constraint of land availability was blamed by 20% of the farmers, while 60% of the households in the study claimed that labour was a constraint to cultivating more land. 80% of households felt they did not suffer land constraints because they did not have enough labour to force demand on the land. However, households with little family labour were vulnerable to labour shortages, particularly during times of peak demand such as during planting and weeding. These households were also vulnerable to cash shortages because the low number of males in the household restricted their ability to undertake extensive off-farm activities. 45% of the farmers said that a lack of cash had discouraged them from investing in extra labour to meet peak demands, and they had relied instead on labour exchange, credit negotiations or support from relatives.

These farmers were restricted to low-investment strategies, such as burning and fallow, whereas high-income households had a better choice of strategy. In addition, low-income families were vulnerable to food shortage. Many claimed to have consumed seed as food during the dry season and were unable to replace their seed stores before planting. A lack of good seed was held responsible for land being left in fallow by 35% of the farmers.

In addition, some 70% of the farmers blamed poor soil quality for the extent of unintentional fallow. In the opinion of the farmers, the relationship between poor soil and poor rainfall was an important reason for unintentional fallow. They claimed that in a year with poor rainfall, the areas that had poor soil were most at risk of crusting, runoff and erosion and unable to retain much soil moisture. While these farmers were forced to leave their land fallow at the beginning of the season, 90% of the sample farmers included land that was abandoned to fallow because a combination of poor soil and droughts during the agricultural season. Farmers who planted immediately after the first large rainfall, were most likely to have abandon land to fallow if there was an early season drought. 65% of farmers said they preferred to plant after the second rainfall event to minimise the risk of abandonment. Figure 6.24 shows that the area of fallow for the twenty farms increased during the low rainfall years of 1991-1995. In 1998, the rains came late in the season, making planting risky and many farmers abandoned mid-season work on *tassi* plots in favour of work on better soil types. However, only 5% of households considered a late season drought to be more serious than an early season drought and only 5% mentioned flooding as a reason for abandonment.

Figure 6.24: Fallow and rainfall for 1991-1995

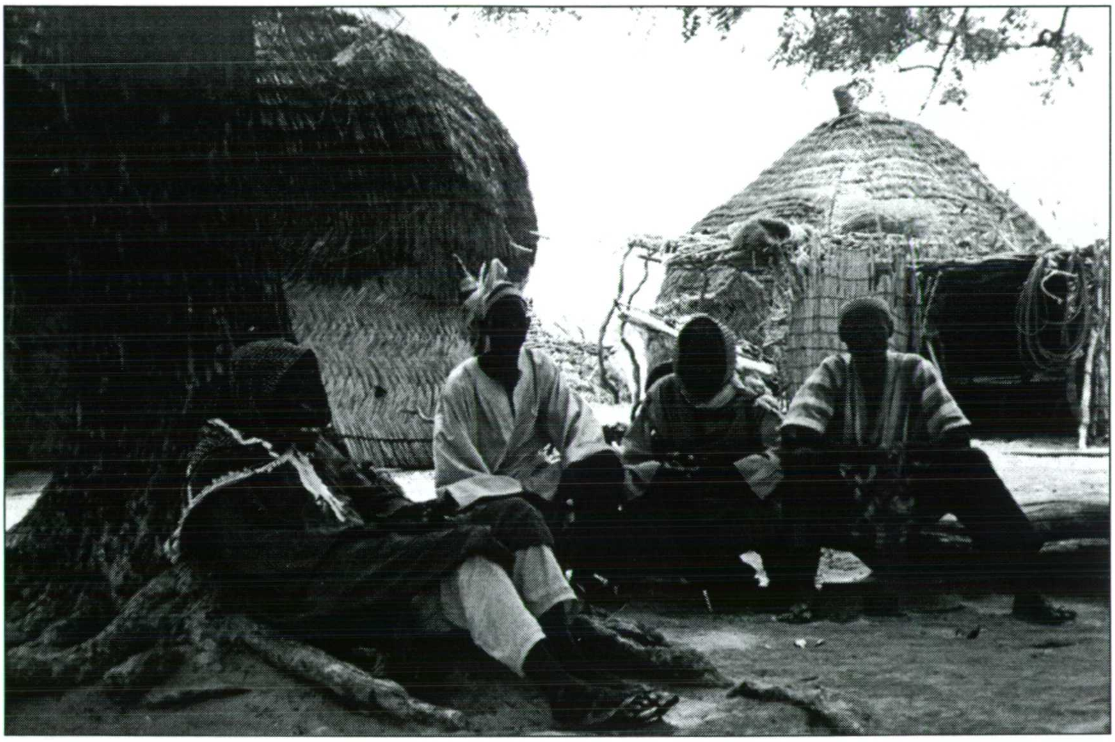


Farmers observed that droughts following the first rains also brought the risk of swarms of insects and other pests, such as worms, birds, grasshoppers, locusts or caterpillars. The farmers claimed that the growth of grasshopper and locust swarms were controlled by the first heavy rainfall events, when many were drowned or swept up by the convective storm clouds. 75% of farmers cited serious pest attack and weed increase as reasons for abandonment to fallow. Low-income families were unable to replace the crop or to buy pest control, such as rat poison.

Towards the end of the agricultural season, families were at most risk from sickness, having worked hard on the farm with little food. Illness and tiredness affected 20% during the study period (plate 6.1), reducing the labour force at a critical time of the year. Only those who were able to negotiate labour replacement, from neighbouring farmers or from family, were able to continue cultivation on all the fields they intended to cultivate at the start of the season.

There is thus a good body of evidence that farmers, while they appreciate the ecological benefits of fallow, do not voluntarily practice it except as bush-fallow on distant fields. They may intentionally short-fallow poor soils in the village zone, but as Mmopelwa (1998) found in his research on unintentional fallow in Mogobane village, in semi-arid Botswana, they do this only not if they are unable to use other soil fertility improvements. Mmopelwa (1995) had earlier suggested that socio-economic and climatic conditions, which were beyond farmers' control, were also influential in fallow management at the farm scale. Soil quality was responsible at field level, if there were household labour and capital constraints. This issue requires more attention and the most statistically significant factors in constraining soil fertility improvement are discussed in section 6.2.3.

Plate 6.1: Farmers resting in the village after planting in May 1998



6.2.2.6 Summary

Soil quality, labour availability, wealth indicators (specifically livestock numbers), and the size and distribution of the farm were analysed as determinants of Djerma land allocation (into fallow or cultivation). The analysis showed that, at the plot-scale, fallow was found on poor *tassi* soils and that the length of time in fallow on these soils was longer than for other types of soil. This suggests that some of this fallow was part of a deliberate strategy of soil improvement for low-income families. Fallow on other soils, and also on fields belonging to wealthier families or large families, was only left for one season, indicating temporary misfortune, drought or labour constraints. The farmers claimed there was less unintentional fallow on *gangani* and *korobanda-tassi* soils than *tassi* soils during good rainfall years because the former had high levels of mulching and better soils.

In addition, farmers who had a high land-to-labour ratio left plots of land away from the village in permanent to long-term fallow, whereas farms with a high labour-to-land ratio were managed more intensively. Fragmented farms had more land allocated to fallow than farms with larger contiguous areas, especially if the fields were close to the village. Large families (defined here as having a high weighting in terms of labour units) were better able to manage fragmented farms than small families because of their responsive family labour force. As a result, large families were able to cultivate more fields than small families.

Closely related to household demography is household wealth, which farmers believed was synonymous with livestock ownership. Households with many livestock cultivated more fields and had less fallow than those with low livestock ownership and little access to this method of soil improvement (manuring or corralling). The wealthier families were also better placed to arrange for paid labour during peak demand, making them less likely to abandon land to fallow than those households dependent on labour exchange or small family labour units. The analysis additionally indicated that a small farm does not suggest a low-income, since some small Djerma farms had high numbers of smallstock.

6.2.3 Constraints on soil fertility improvement

An inherently risky environment with variable rainfall and poor soils, which gives little promise of returns, is not conducive to investment in soil fertility improvement. Moreover, the present analysis shows that farmers also do not have the capacity to invest in soil fertility because they have limited access to capital assets, such as labour, cash, or livestock.

- Household size

  Small households are vulnerable to labour shortages at bottleneck periods in the agriculture season. They also find it difficult to boost household capital, as from off-farm activities, because to do so reduces labour availability at the start of the rainy season. Small households are not necessarily poor households, although small households to remain viable must depend on family support networks. If a household has few women, it does not have the capacity to look after many sheep or goats, a commercial task predominantly performed by women. This frequently restricts access to organic inputs to fields.

- Income

  Low-income households are unable to buffer themselves from risk, with investment in livestock for example, which would increase their access to manure. Low-income families are dependent on fallow to improve fertility (figure 6.16). Households with little capital are more dependent on family labour than richer ones (figure 6.25). If the household is small and financially constrained, the farmer has limited ability for labour-intensive investment, such as producing and applying organic fertilisers (manure, compost and termitaria soil) or practising soil conservation. The household is also likely to have a shortage of animals and limited capacity in transport of manure to those areas where it is most needed. Instead, they are dependent on methods that are not labour-intensive, such as burning, mulching or fallowing. Furthermore, low-income Djerma families are unable to afford to pay Fulani to graze their cattle on the crop residues or fallow to gain from the manure that the animals leave behind. These families are most vulnerable to droughts, which can inflict significant losses on valuable livestock and this can affect a whole family enterprise. As they have limited choices, it is common for household members to seek off-farm cash to solve constraints.

- Farm size, field location and fragmentation

  The size of the farm and location of its fields affects the type of soil fertility improvement method that is employed (figure 6.26). On large farms with large fields, extensive methods are practised, predominantly fallowing, while on small farms or small fields close to the village intensive methods are practised. Distance of a field from the household compound affects the return to labour investment and consequently the highest average millet productivity is found in the 'village field' zone, where fallow rotation and manuring is practised. Fragmented land holdings require a higher labour investment to maintain soil fertility. Farmers rarely transport manure to out-fields, preferring to corrall animals on those fields or to depend on passing herds for their manure. Fortunately for most farmers, these out-fields have lower intensities of use and *botogo* or *gangani* soils, which require fewer inputs to maintain yield.

Figure 6.25: The relationship between household income and the use of family labour

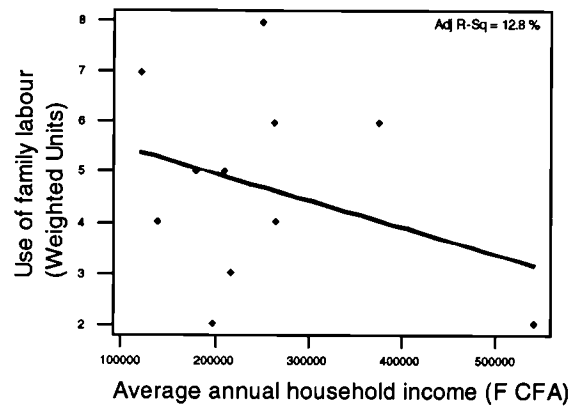
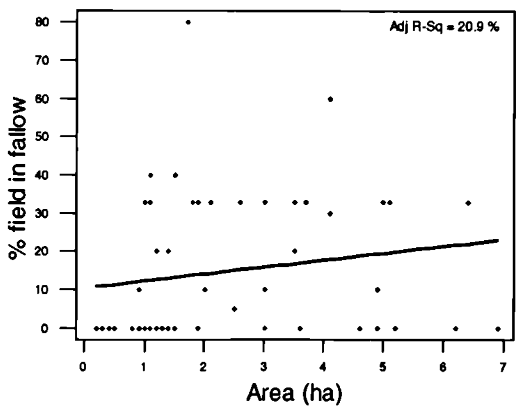


Figure 6.26: The relationship between field area and percentage of field in fallow



- Tenure insecurity

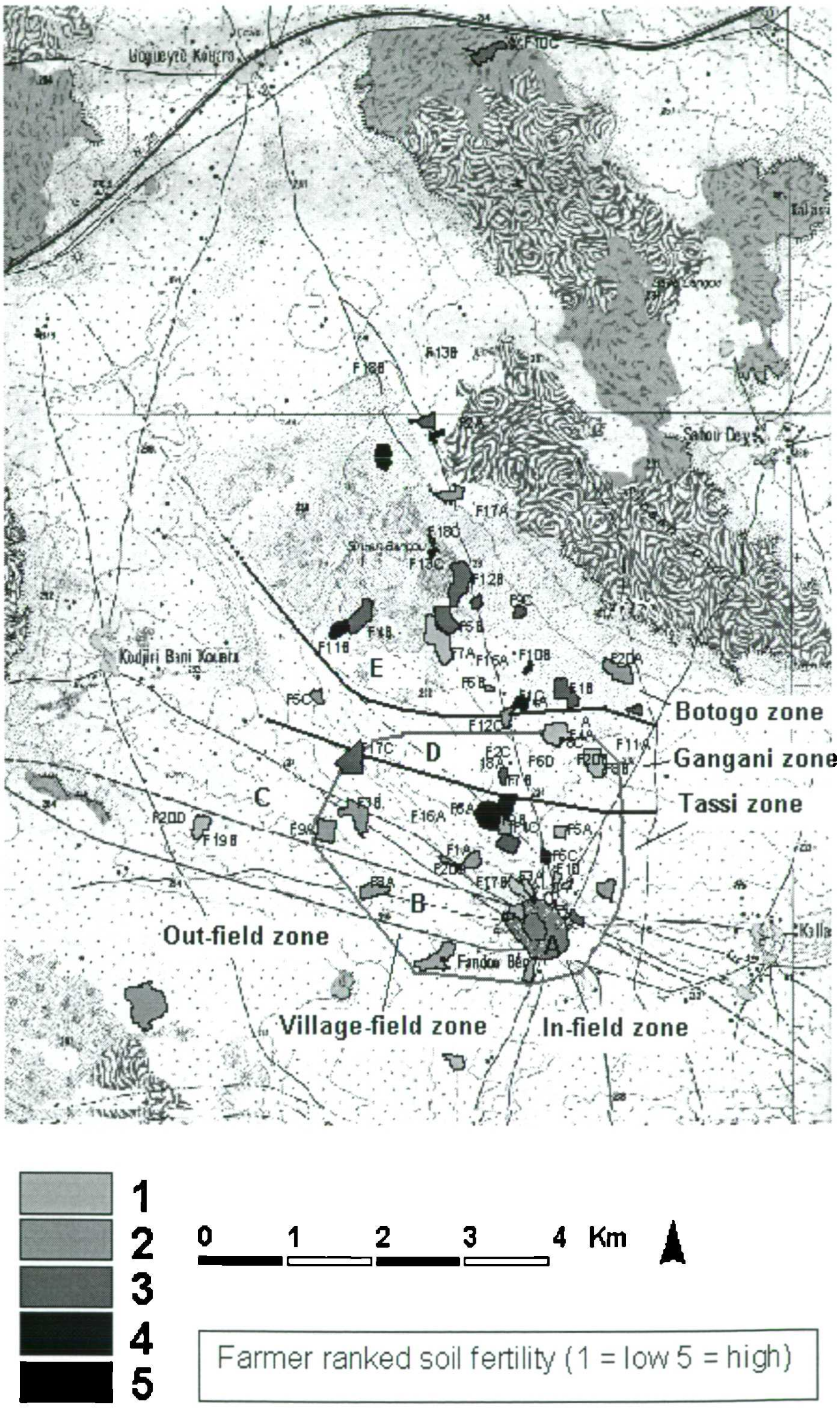
  Tenure insecurity in the 'village field' zone appears to be constraining the length of time that parts of the fields are put into fallow and prevents large parts from being left in fallow. Although this is partly the result of increasing demand for land, it is also partly the result of the decreasing returns to labour with distances of a field from the compound, and of farmers' perceptions of interactions between soil type and rainfall (as discussed in Chapter Five). For these reasons, it is uncommon for the farmers in the sample to lend fields in this zone unless they are unable to cultivate the land because of labour constraints. There is an argument in policy circles that a private tenure law would create a sense of security and stimulate investment, but this effect cannot yet be observed in Fandou Béri. Without the support for soil fertility investment in this variable and unpredictable farming environment, returns to labour are risky, and taking advice and credit outside of informal networks is currently impossible for farmers. Tenure is discussed further in Chapter Seven.

6.2.4 Spatial expressions of diversity

6.2.4.1 Farmer perceptions of soil fertility in relation to indigenous and agro-scientific maps of soil class

Spatial patterns of differentiation can be displayed using a GIS (ARCVIEW). One of the hypotheses of this study is that physical attributes influence the spatial pattern of field use and soil fertility. Map 6.1 shows the pattern of 'farmer-ranked soil fertility' in the sample fields. Most of the low fertility fields are sandy soils, locally classified as *tassi* and most of the higher fertility fields correspond to areas identified as *korobanda, botogo* or *gangani* soils. The farmer-defined soil zones and field-type ('in-fields', 'village-fields' and 'out-fields') are labelled on map 6.1 (A-E see table 6.5). Anomalies in the pattern are partly the result of additional inputs made by farmers and partly a reflection of rainfall conditions, as discussed in Chapter Five. Map 6.1 also shows the diversity in perceived soil quality between fields on the same farm. Any skew in data patterns can also be attributed to the outlying compounds and soil class distribution, as discussed in Chapter Four.

Map 6.1: Farmer classified soil fertility

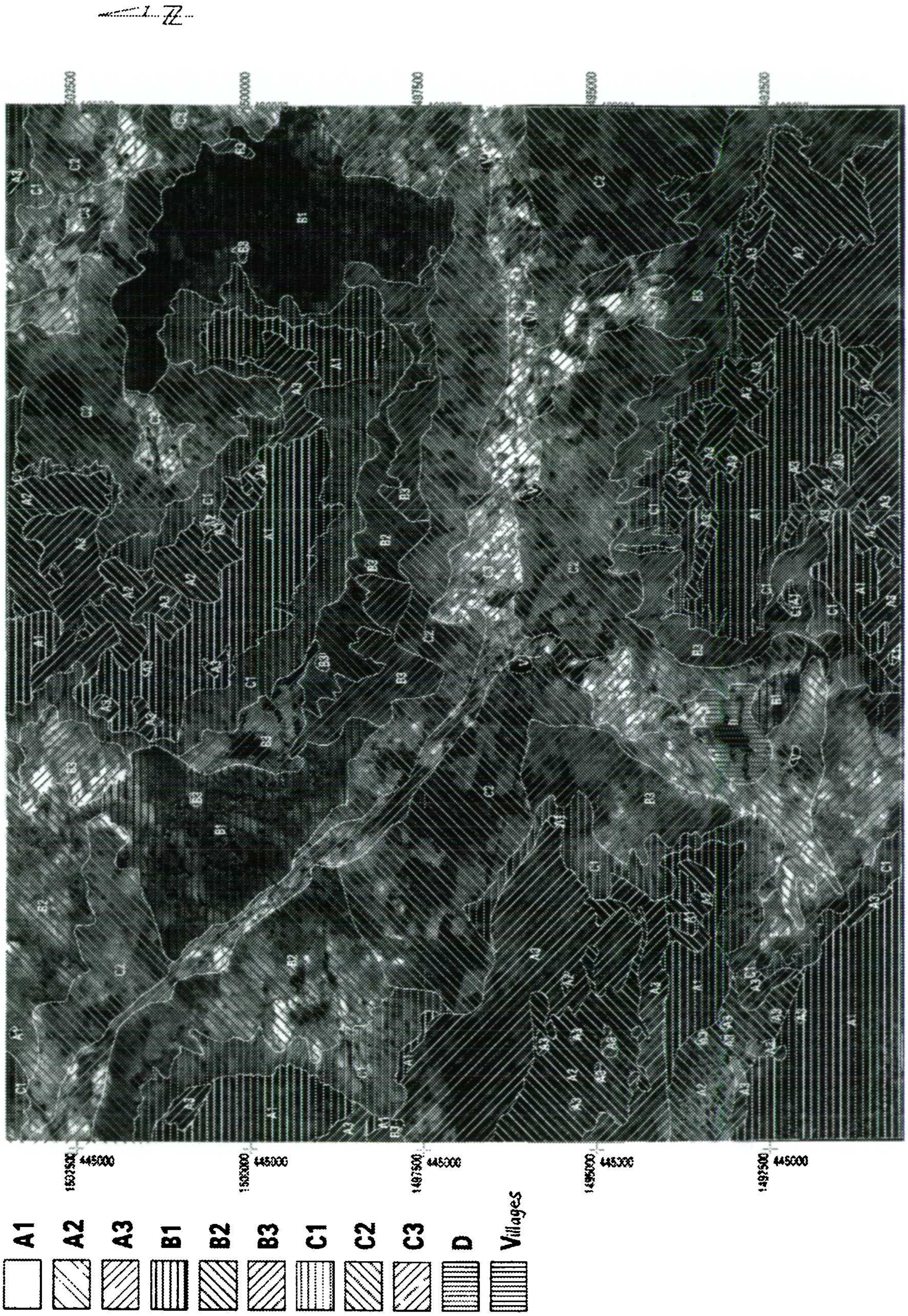


Comparisons between Legger's (1993) scientific soil survey and the fertility classes are also not straightforward (Osbahr and Allan, submitted). The agro-scientific map (map 6.2) is based on an abstract classification, based on colour, texture and chemical composition. However, as discussed in Chapters Four and Five, farmers' perceptions of soil fertility are linked to physical location, although they also use colour, texture and infiltration capacity. They also include anthropogenic and historical factors in their fertility assessment. It is with this dynamic meaning that the agro-scientific classification fails to engage.

Nevertheless, the soil units on map 6.2 do correspond quite closely to the soil unit described by the farmers:

- C3 (valley aeolian cover sands with rapid drainage except in gleyic pockets) Podzols and Arenosols = types of *tassi* and *botogo*
- C2 (valley dune sands prone to crusting and erosion) Ferralic Arenosols, Rhodic and Haplic Ferralsols = types of *tassi* and *gangani*
- B3/2 (flat valley terraces of discontinuous plinthite covered in places with a layer of aeolian sand or red gravels) Arenosols and Cambisols = plateau and stony patches known as *tondu*

The scientific classification is based on pedogenesis and chemical analyses whereas the farmers' soil fertility categorisation is embedded in conceptions of the wider agroecological system. Although the farmers appear to be using readily identifiable characteristics for their classification of soil fertility (see Chapters Four and Five), which correspond to those used in the scientific system, the two systems understand soils in essentially different ways. Farmers considered the relationships between soil types to be multi-dimensional and individual soils, for them, seen in different ways (e.g. depending on geomorphological landscape, drainage, and potential for agriculture and specific crops, organic matter). Scientific soil classifications are based on a unique, multi-level hierarchical taxonomy. Other researchers make similar comments about this contrast (Allan, 1997; Thiombiano, 1995; Winklerprins, 1999; Mazzucato and Niemeijer, 2000). The local perception of the interaction between soils and the place in the landscape could nevertheless be important for scientific understanding (e.g. in soil geomorphology and topographic analysis).



Map 6.2: Agro-scientific soil map covering the Fandou Béri territory (source: Legger, 1993)

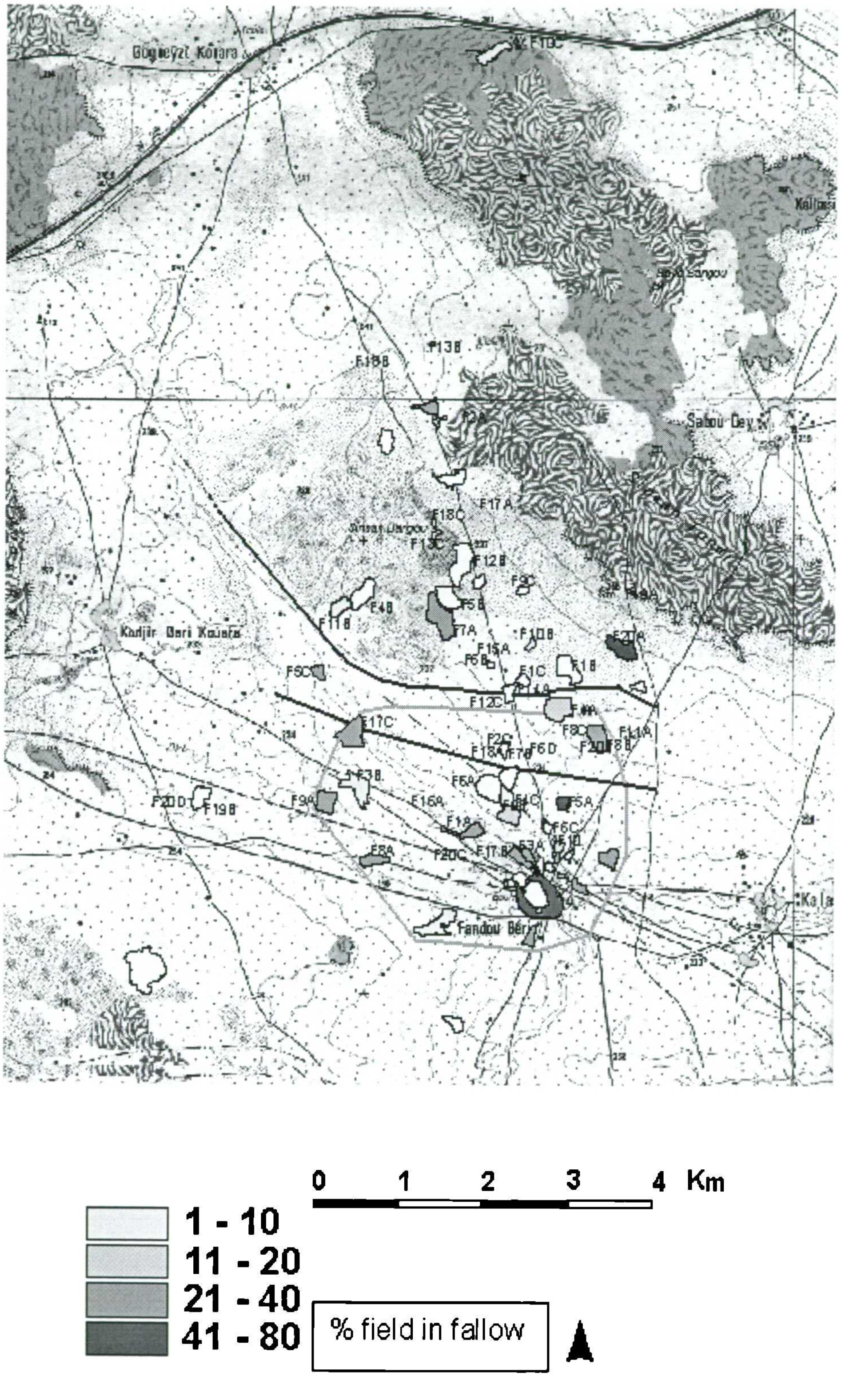
6.2.4.2 Zones of land management practice

A terminology of land use zones exists in the literature. Prudencio (1993) described the pattern in farm management that occurred in many West African semi-arid villages (see also Ruthenberg, 1980). The rings are the result of the spatial pattern of farmers' management of the soil and crops. In broad terms, the concentric ring pattern is one of decreasing intensity of land use with distance from the village.

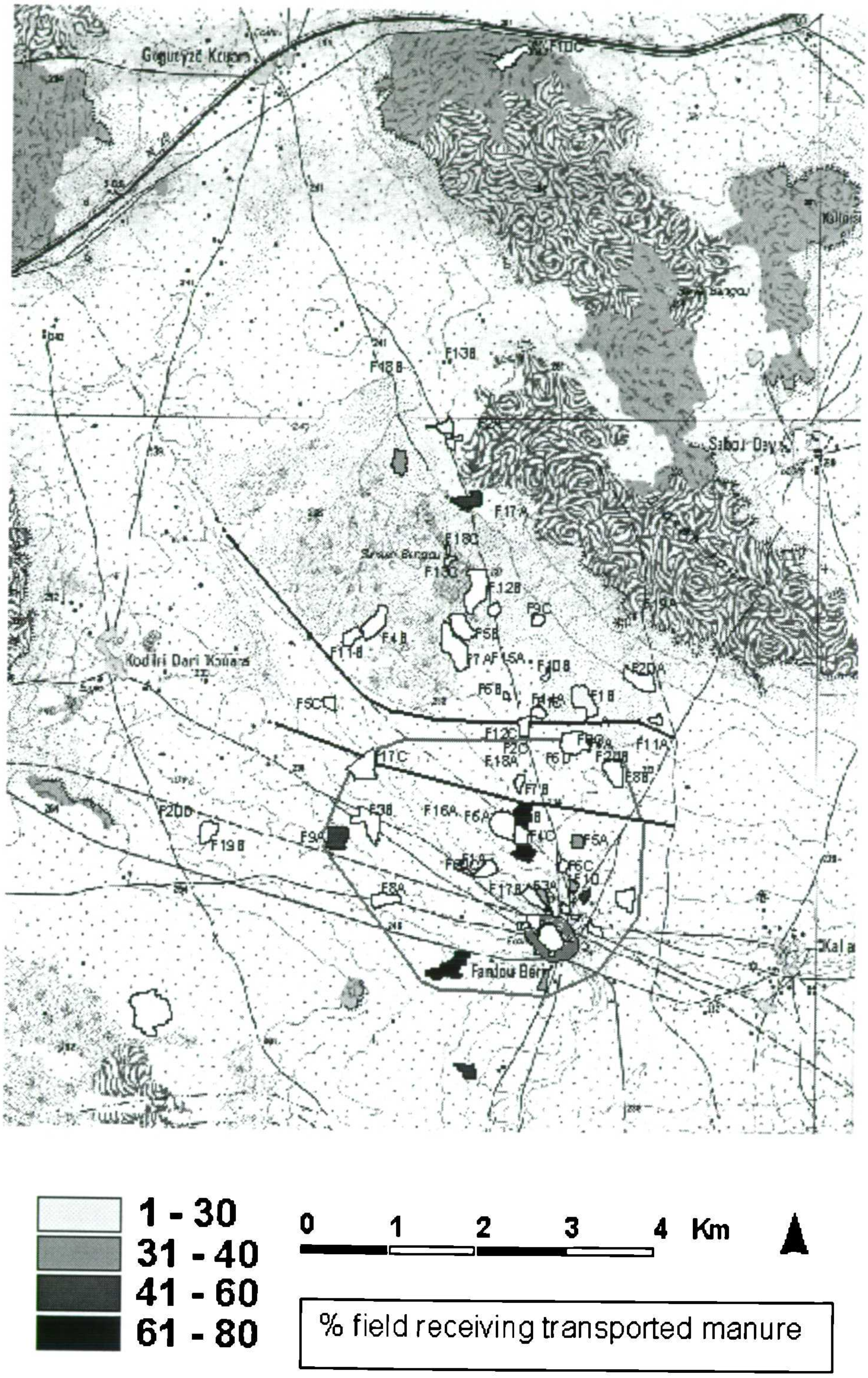
The terms 'in-field' (adjacent to the compounds), 'village-field' and 'out-field' (furthest away from the village) were shown on map 6.1. These terms correspond to farmers' perceptions of location of their fields. However, the diversity in farming constraints and opportunities, and the fragmentation of farms, means that these ring systems are not as distinct at Fandou Béri as the literature suggests (and one suspects that they are never so distinct). As Prudencio (1993) observed, the one element that is distinct in all reported cases, as it is at Fandou Béri, is the household compound at the centre. This suggests that the terminology is more appropriate when applied to patterns based on the individual farm rather than to the village as a whole.

Chapter Five identified the use of low-technology soil fertility management practices: fallowing, manuring, mulching and composting. The respective representations for the percentage of these practices on each field on the farm and their position in each zone are given in maps 6.3, 6.4 and 6.5 and the average characteristics of these zones are presented in table 6.5.

Map 6.3: Percentage of the field in fallow in 1998



Map 6.4: Percentage of the field receiving transported manure in 1998



Map 6.5: Mulching/composting as a percentage of the field in 1998

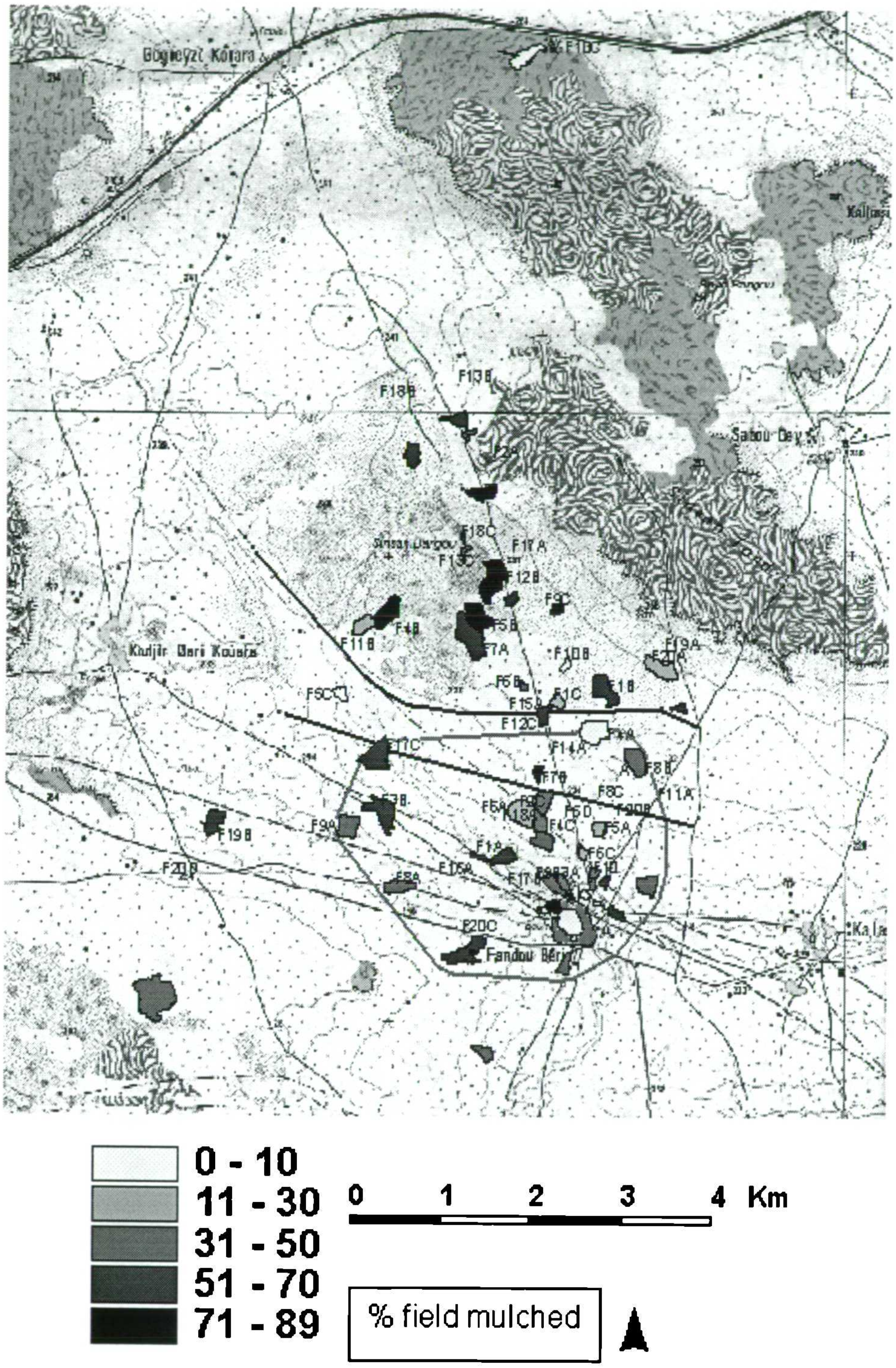


Table 6.5: Characteristics of zones

Characteristics	**Soil Zone**				
	A *tassi* **in-fields**	**B** *Tassi* **Village-fields**	**C** *korobanda -tassi* **out-fields**	**D** *gangani* **out-fields**	**E** *botogo* **out-fields**
Average distance of fields from compound (km)	0.3 (0.039)†	0.7 (0.186)	2.2 (1.070)	4.1 (3.351)	2.3 (1.439)
Average field size (ha)	1.5 (0.612)	2.7 (2.091)	3.6 (3.083)	3.5 (2.292)	1.8 (0.997)
Crop mix - % cultivated zone planted with:					
Millet-cowpea	89	76	100	88	100
Sorghum	0	8	11	38	78
Other	11	38	44	75	78
Distribution of local soil types - % field area per zone:					
Tassi/korobanda	100	90	90	20	30
Gangani	0	0	5	70	10
Botogo	0	10	5	10	60
Zone area as % of total cultivated area	7	20	37	12	9
% fertilised with transported manure	26	5	26	8	26
Mean frequency of corralled/ grazing inputs (in past 6 years)	0.3	0.8	0.7	0.5	0.5
% field fallowed (last 10 years)	30	60	40	5	3
Average number of years in cultivation**	20	4	3	6	8
Average number of years in fallow**	1	3	4	2	2
Land use intensity (man-hours per ha per day) before harvest*	2.7	3.4	2.8	1.5	1.8
Number of sample fields	9	13	19	8	9

(*) Labour converted to man-hours. All averages are computed by aggregating fields in each area and are thus adjusted for field size (**) As part of the rotation system (†)Variance

Section 6.2.2 identified relationships between land investment and practice and household endowments, which can also be seen in the patterns shown on maps 6.3, 6.4 and 6.5. General observations can be made in reference to the maps and table 6.5 (note that the long-term bush fields are not marked on the maps):

- *Zone A. 'In-fields'*: fields in this zone, closest to the main village and the wells, were used either for continuous cropping or semi-permanent cropping (20 years average in cultivation). The in-fields primarily supported a millet and cowpea intercrop for subsistence use, with pockets of the cash crops groundnut and hibiscus. *Tassi* fields in this zone received household waste and manure from compound animals. The fields were small in size, an average of 1.5 ha, and had the small percentage as fallow, all short-fallow. However, despite the long periods of cultivation, proximity to the village and relatively high levels of organic inputs resulted in a high land use intensity value of 2.7 labour units per hectare.

- *Zone B. (Tassi 'village-fields' with patches of botogo in rainy-season gullies).* Fields in this zone were larger (averaging 2.7 ha) than those in zone A, yet a lower percentage of their area was cultivated (an average of 60% was in short-rotation fallow). Although this zone was also used to grow millet-cowpea intercrops, more cash crops were grown, as were pockets of sorghum on *botogo* patches. The short rotation permitted land to be left in fallow for an average of 3 years (4 years average in cultivation), but soil fertility was only supplemented with transported manure and organic inputs from corralling over an average of 5% of the field. Farmers had to walk an average of 0.7 km to reach the village zone but the zone had the highest land use intensity value of 3.4 labour units per hectare.

- *Zone C. (Tassi and korobanda 'out-fields').* This zone had the largest average field size (3.6 ha), but the lowest intensity of cultivation per field (as a percentage of the total area). This was because the short-fallow rotation system (4 years average in fallow and 3 years in cultivation) covered 40% of an average field. The zone had lower land use intensity (2.8 labour units per hectare) than the village-field zone, but pockets of *gangani* and *botogo* soil supported a higher variety of planted crops. The zone had a similar percentage of the average field covered with transported manuring as zone B but corralling was more common. Mulching was commonly practised. The average distance from compound to field in zone C was 2.2 km.

- *Zone D. (Gangani 'out-fields').* These fields have an average size of 3.5 ha and an average distance of 4.1 km from the compound. They support a wide crop mix and have large pockets of different soil classes on each field. The average fallow rotation is short (2 years), but the average cultivation period is longer (6 years) and only 5% of the average field is in fallow. The zone has low inputs of transported manure but there is more corralling than in the *tassi* zones. However, land use intensity is the lowest (1.5 labour units per hectare), a reflection of the smaller *gangani* area as a percentage of the total cultivated area.

- *Zone E. (Botogo 'out-fields').* These fields (averaging 1.8 ha) were used to grow the widest variety of crops, in particular sorghum, peanut and sesame. The mean frequency of transported manure applications was lower than in the other zones, even given the small area as a percentage of the total area in cultivation in this zone. However the cluster of compounds to the north of the territory inflated the percentage. The area also received corralled inputs because of the proximity of the zone to the plateau, which is used for grazing. Land use intensity was low (1.8 labour units per hectare), given the average distance of 2.3 km to fields, but the zone had the highest average for mulched area. However, these fields had the lowest average field percentage in fallow: the fallow rotation system averaged 8 years in cultivation and 2 years in fallow.

These general statistical characteristics are not especially useful for the understanding of the household management of micro-variation. Using the database information and analysis in section 6.2.1, which includes other variables such as field history, the location of different types of cultivation can be better discussed in terms of diversity in soil and crop management. Thus, a pattern of fields with similar management can be identified on the maps using the statistical groups in section 6.2.1. When this analysis is performed it becomes clear is that the diversity in the zones is more a function of household type. Thus, a clear pattern of use for each zone by household and a less clear pattern of use by the village as a whole can be seen on the maps.

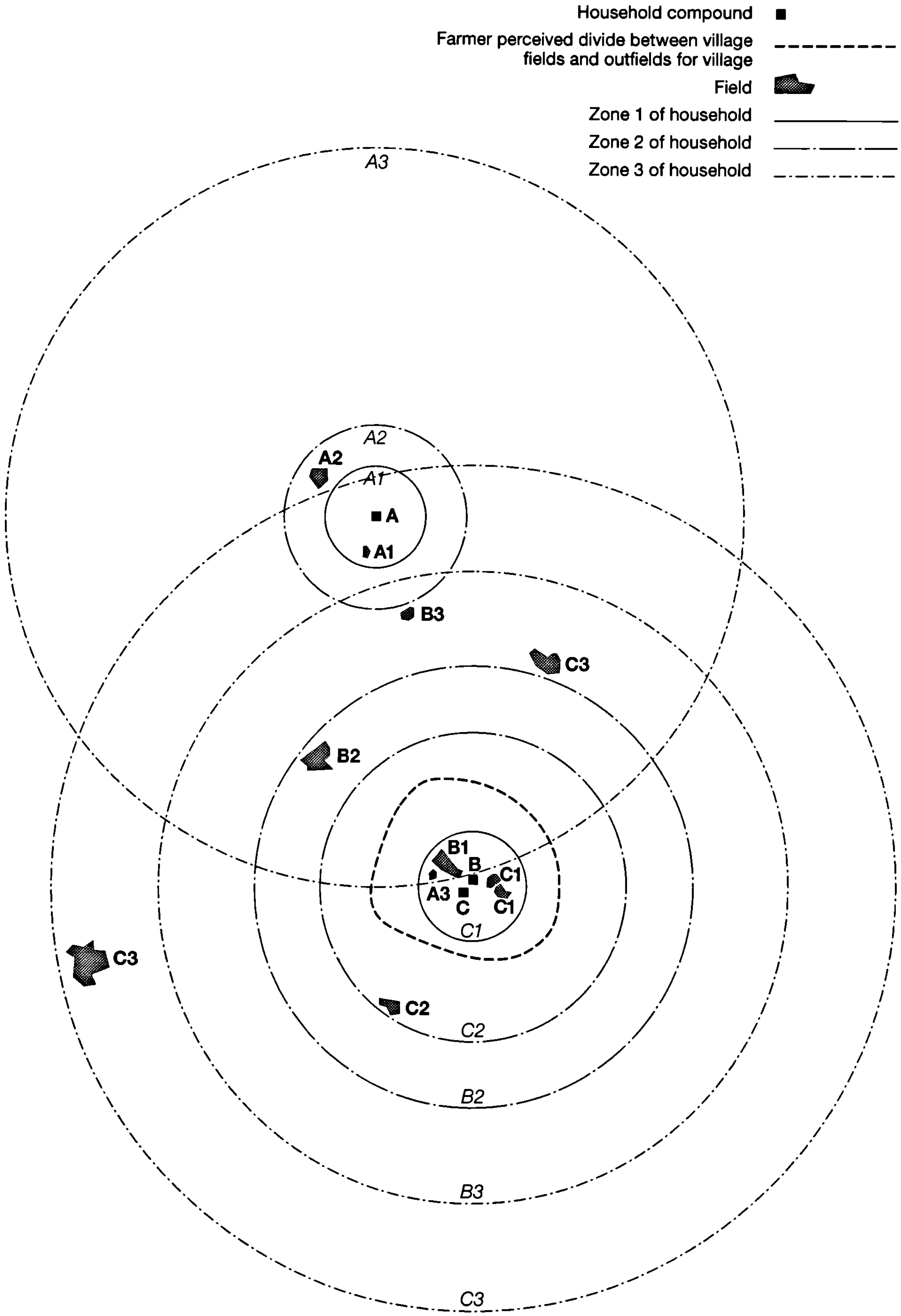
Although the overall spatial pattern of land use is generally consistent with the terminology used in other Sahelian studies, so that most of the first zone is composed of in-fields, a first zone field is not necessarily an in-field. In like manner, a distant field is not necessarily a bush field; it could even be an out-field, or if that household's compound is outside the village settlement, it could be an in-field. These types of exception apply specifically to the Fulani and the chief's compounds. Examples of this effect and the zones around individual households are shown in figure 6.27. The rationale of the pattern from the farmers' point of view is given in section 6.3. Field zones around the household can be seen in the context of the patterns based on farmers' perceived soil fertility or the soil class (map 6.1). The relationship between distance and soil quality was identified in section 6.2.2. The relationship between field location, soil type and distance is most distinct when based on the individual farm (unlike traditional distance analysis that is based on the village centre).

The map analysis contributes to an understanding of the relations between land type, soil fertility zones and land management practice, but used alone, it fails to explain actual patterns. This is because soil class/fertility is not a significant variable on its own right (on a farm scale) but part of a set of other socio-economic themes. There is not a simple pattern of rings because of the specific locational micro-diversity of soils at the field-/plot-scale and because of the interaction between rainfall and soil type in determining fertility.

6.2.4.3 Representations of the relationship between soil zone and resource productivity

The review at the beginning of this study identified a common hypothesis in the agro-scientific literature to the effect that 'traditional' farming systems in the West African Sahel, and sub-Saharan Africa in general, inevitably mine the natural fertility of the soil, as they evolve towards more permanent cultivation. The consequence of this argument would be a fall in soil productivity as population density increased and land use intensified. Although it is not possible to assess soil chemical change in this study site, because of the lack of a nutrient budget analysis, the hypothesis can be tested in another way. Given that there is detailed information available on the yearly and average productivity (between 1985-1997) of the fields of the sample farms (map 6.6 for the study period) and further information on the database (table 6.5), it is possible to perform one kind of test of the 'soil mining' hypothesis at Fandou Béri. For example, when labour is related to farm management, and is based on the soil zones and crop calendar (table 6.6), much can be inferred from the patterns of resource use.

Figure 6.27: Relationship between zones and management for three households



Map 6.6: Average productivity of field (kg/ha/yr for millet yield) over study period

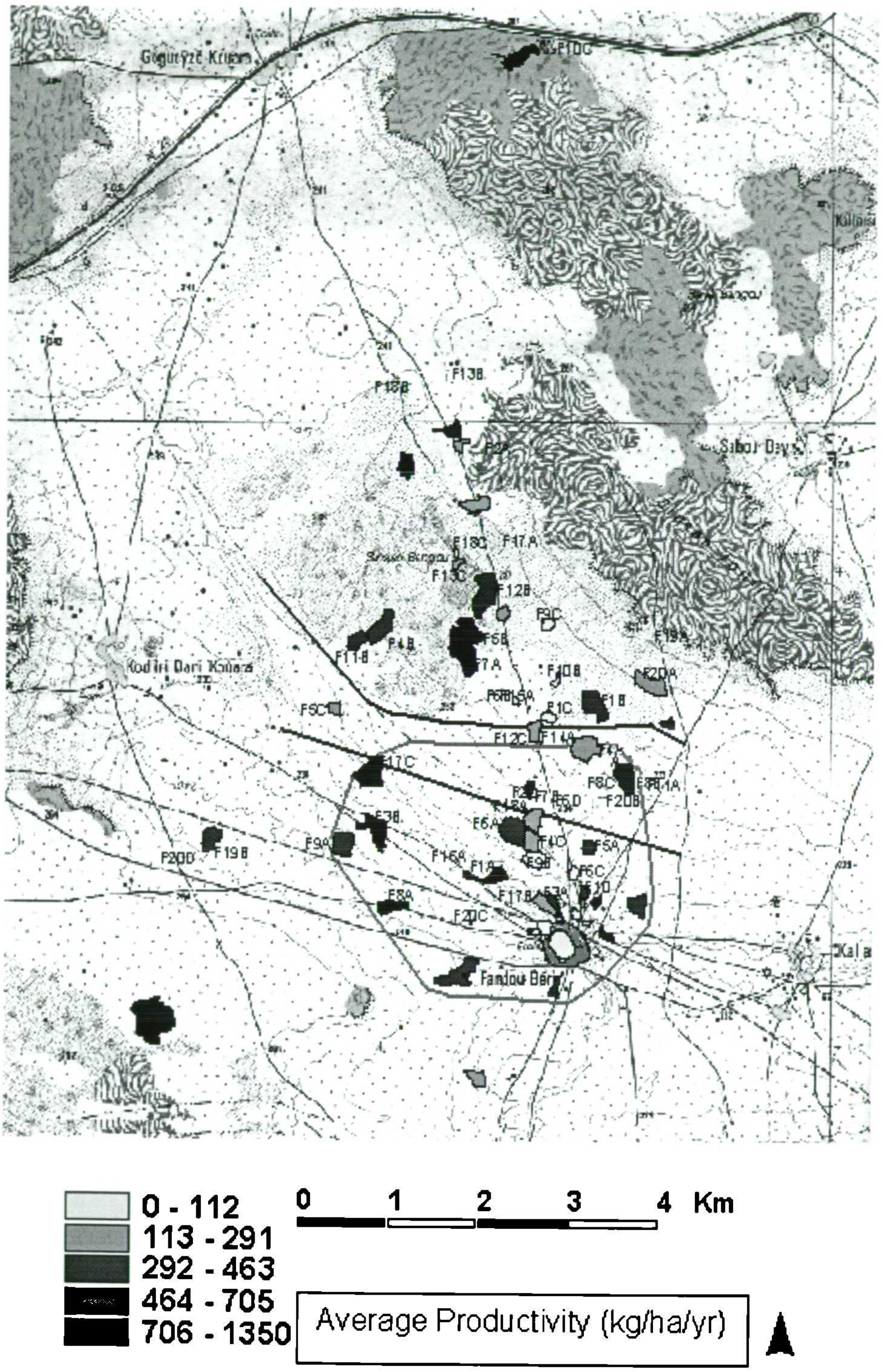


Table 6.6 Labour and timing of operations in Fandou Béri (1997 and 1998)

	Zone				
(number of sample fields)	A(9)	B(13)	C(18)	D(8)	E(9)
1997 CROP PRODUCTION (days spent/field*)					
Preparation	4	10	18	5	7
First millet seeding**	1	2	3	2	3
First weeding	7	16	25	5	15
Second weeding	5	11	15	5	7
First millet harvest	2	8	11	7	9
Second harvest	1	3	3	2	3
1997 TIMING OF OPERATIONS *					
First millet planting date	89	88	86	85	84
First weeding date	113	98	111	112	113
Second weeding date	162	152	154	162	162
First millet harvest date	206	203	205	208	209
Second harvest date	224	219	218	225	227
1998 TIMING OF OPERATIONS *					
First millet planting date	49	47	49	52	50
First weeding date	60	59	61	65	66
Second weeding date	100	100	96	105	106

* *All figures are averages with labour converted to man-days. The figures for the timing of operations are based on day 1 being April 1^{st}*

** *Note that not all of the first seed germinated and many fields had to be re-seeded*

The crop calendar data in table 6.6 indicate that the timing of farm operations (planting, weeding harvesting) was overall better in the *tassi* zones and inner areas, in terms of the time between activities, than in the outer zones. For example, in 1997 the average time lag between planting and first weeding was 10 days in the village-fields, as opposed to 25-29 days in the out-fields. A similar pattern was seen in 1998. The differences in timing were related to the difference in the maturity periods of the main crops and varieties grown, and to the interaction between rainfall and soil type. The differences indicate that the main labour bottlenecks were less severe in the outer zones than the inner zones. For example, millet was first harvested in the village-fields on average 115 days[1] after the first seeding in 1997, while it was harvested on average 119 days after planting in the out-fields. The data in table 6.6 also suggest that on average greater amounts of time were spent working on *tassi* village- and *tassi* out-fields than in the other soil areas, although the *botogo* out-fields had experienced a higher level of labour input during the first weeding (a reflection of the activities of the chief's family). The results support the existence of a zonally organised system of

[1] The average length of the growing season is approximately 120 days in Fandou Béri. Seybou (1993) gives a figure of 108 ± 23.7 days for the region.

management for soils and crops at farm level in the research area, such that management and the intensity of land use are correlated to field-compound distance.

A similar pattern of intensity of use by zones was found in the village of Kolbila in the Sudan-Sahel zone of Burkina Faso (Prudencio, 1993). Prudencio also identified a pattern of soil fertility change corresponding to the zones, using the results from soil chemical analysis. As at Fandou Béri, Prudencio (1993) found a positive relationship between average returns to labour and the intensity (labour input per hectare) of land use within the farm (table 6.6). The fields nearest to the village received the most intensive management.

Because of the focus on the relationship between labour returns and distance in the study by Prudencio (1993), it failed to examine the role of rainfall on productivity. In Fandou Béri, the farmers claimed that the influence of rainfall on soil productivity and rainfall was as important to them as the influence of labour. In earlier studies of both Djerma and Fulani land management, rainfall has been found to be central to local perceptions of soil productivity (Manu *et al.* 1991; Krogh and Paarup-Laursen, 1997; Allan, 1997). Manu *et al.* (1991) reported that in 'good' rain years, crops would be sufficient regardless of soil nutrients, while in years of lower or more erratic rainfall, low soil nutrients became the more important limiting factor. Farmers in Fandou Béri also reported that they considered, at the field scale, the temporal and spatial distribution of rainfall during the growing season to determine the relative productivity of the soils more than the inherent quality of the soil itself. Since productivity was considered by farmers to be determined by the interaction between soil qualities and rainfall, their division of soil types was a reflection of these qualities (see Chapter Five; Osbahr and Allan, submitted). Thus, the ethnopedological framework is based around perceptions of how soil qualities interact with rainfall to affect productivity.

The productivity of the soil zone is therefore influenced by the way in which the farmers seek to manage rainfall uncertainties and maintain yields. However, this relationship does not change the pattern of intensity identified, because the *tassi* soils, considered the most fertile under 'bad' rainfall regimes and therefore planted first, are primarily situated around the village whereas the other soil types included in 'good rain' years are further away. Under a 'good' rainfall regime the productivity is higher from all soil types but in particular from *botogo* and *gangani*. Therefore, the farmers' perception of productivity, as the interaction between rainfall and soil zone, makes the field zone as important as distance from the compound.

6.2.4.4 Summary

The GIS has provided a tool with which to understand farmers perceptions of diversity. First, a map of farmers' perceptions of soil quality was compared to an agro-scientific classification for the territory. The comparison identified similar soil units, with similar identifiable characteristics, but it was also seen that these characteristics were understood in essentially different ways. Farmers' perceptions of soil class were contextualised in physical location, embedded in a historical process, and were influenced by a wide range of interactions, including rainfall and human agency. Most significantly, these perceptions were dynamic whereas the agro-scientific classification was static.

Second, patterns of low-technology soil fertility practice (fallowing, manuring, mulching) were viewed in the context of the farmers' soil classes. Sample fields were delimited as 'in-fields', 'village-fields' and 'out-fields' by farmers, a terminology analogous to that used by ring management systems, and combined with the farmers' soil classes this differentiated distinct zones with different characteristics. The analysis showed that the pattern of management in Fandou Béri was more complex than a simple 'ring' structure, given the diversity of household type, short-distance rainfall variation and the micro-diversity of soils at the plot level. Traditional distance analysis does not allow for this diversity which is a central feature in Sahelian villages. Some of the diversity between households could be explained by the location of the fields of the individual farm in each zone and the influence that each zone brought in terms of soil type. For example, *tassi* village-fields were the most intensively managed because of their poor soil quality, the demand for land in this zone and the proximity of the fields to the village, which reduced labour costs.

Lastly, when the labour and timings of farm operations were considered, relating to zone productivity, it became clear that these inner *tassi* zones were receiving the highest labour investments and were managed most efficiently in terms of labour.

6.3 Understanding diversity – examples of differentiated strategies

The quantitative data have provided an insight into the multidimensionality of the influences on patterns of land use management practice, the determinants of land allocation and local constraints on soil fertility improvement. However, although general trends have been identified, the statistical analysis masks the diversity among farmers. The statistics at best provide a 'snap shot' of land use and reinforce the adoption of simplistic assumptions about 'evolutionary' mixed farming models. They suggest that better management and land use allocation accompany increasing intensification, but, clearly the situation is not so simple. The weak relationship in many of the quantitative analyses indicates that statistics mask complex diversity. The statistics are not able to show that the process of land allocation is individual and that farmers' decisions are sequential. Each outcome is specific to a farmer at one time. There is also a history to decisions that cannot be fully understood if analysed with statistics alone. Land allocation patterns are a reflection of differences in inter-annual rainfall and management decisions are a reflection of a dynamic asset-base of a household. For a full understanding of patterns of difference between farmers' land management practice, the statistics need to be complemented with qualitative inter-household examples.

This section presents seven examples of differentiated strategies, selected from households in the village (table 6.7). The aim is to illustrate some of the ways in which smallholders respond to circumstances. Beginning with their endowments of land and labour, and how these change from year to year, the examples proceed to brief descriptions of how they manage their land and labour resources, and how they dispose of the latter among agricultural and other activities from week to week during the representative year of 1998. These examples contextualise the statistical analysis, leading to a fuller understanding of differences in land allocation and soil fertility investment.

Name	Persons	Labour units	Fields	Hectares cultivable	Ha/ labour unit*	No. Cattle	No. Small Stock	No. Donkeys	Income sources
Salifou Hamani (Djerma)	7	3	3	9.8	0.3	1	5	3	Livestock sale, family, petty trade, transport, casual farm work
Oumarou Moussa (Djerma)	10	6	6	21.6	0.3	5	10	0	Crop sale, family, maraboutage
Soumana Adamou (Djerma)	14	5	8	5.4	0.9	32	70	4	Maraboutage, migrant work, sale of livestock and crops
Adamou Soumana (Fulani)	7	3	1	6.4	0.5	24	41	1	Sale of livestock and livestock products, manure exchange
Garba Amadou (Djerma)	12	7	3	7.4	1.0	0	5	0	Migrant work, family and friends, sale of wood, livestock, domestic products, contribution from sons' migrant work and trading
Abdou Ide (Djerma)	8	4	2	2.8	1.4	1	6	0	Migrant work, contribution from sons' migrant work, family, Sale of crops, bricks, wood, livestock, domestic products
Djibo Abdoullaye (Djerma)	10	5	4	5.7	0.9	3	6	0	Sale of livestock, family and friends, contribution from son's migrant work, religious gifts

**Weighted man-hours*

Table 6.7: Six Sahelian households in 1998

Case Study 1

In 1998, Salifou Hamani lived in the main village settlement with his two wives, children and extended family. Although his household numbered seven, the weighted labour force in the household reached only three units. He had two young sons, but only the eldest, who was aged 11, was learning to help on the farm. Salifou Hamani was already 57 years old and said that until his children grew older, it was difficult to farm intensively without help from beyond the family.

Although the family had little endowment of labour, it was well endowed with farmland compared to many others in the village. The farm was 9.8 ha, above the average for the study sample. It was fragmented and consisted of three fields that were inherited from Salifou's father. He considered one an 'in-field', close to the village (0.5 km), but at 1.1 ha it was small. He considered this field to give the best production because its proximity made it easiest to work. He managed the field as a fallow rotation system of three years in fallow and four years in cultivation. In 1998, only a small proportion was in young fallow. The other two fields were situated in the 'village-field' zone, both 1.7 km away. These fields were large, one at 3.7 ha and the other at 5 ha. He believed the largest to have the best soil because over a third of it was regularly left in fallow to improve the soil fertility. These fields were managed on a rotation system of two years in cultivation and three years in fallow. Both had over a hectare in short-fallow (two and three years respectively). He claimed that he could match the production per hectare, currently in practice on his farm, on any new field, if he could only leave more of the farm in fallow. He thought this would be a good strategy for improvement and he hoped to borrow another field to allow him to do this. However, he was nervous about this strategy for fear of risking the family's rights to the land. He also was concerned by conflicts that had arisen in the village and thought that borrowing land, even from family or friends, would lead to problems.

All the fields were relatively level, with sandy *tassi* soils, and all were bordered by large trees. Salifou Hamani considered these soils good for growing the staple crops during dry years because they held moisture. However, compared to other farms, the soils were rated low in fertility, particularly the barren 3.7 ha field, which was prone to wind erosion, had areas of white *boulougou tassi* and was bordered by *gangani* soils. Micro-variability nevertheless meant that there were areas of higher fertility in this field. The soil under fallow on the 5 ha village-field had fortunately developed patches of *korobanda* crusting. The closest field had a gentle slope leading to a low-lying area of *botogo*, and was prone to wash-erosion during early season rains. The farmer maintained a number of *Guiera senegalensis* bushes on the *botogo* to prevent the silty, fertile sediment from being washed away onto neighbouring fields.

The family kept a number of chickens, a few small ruminants, three donkeys and also owned a cow. Salifou Hamani's 36-year old first wife owned the goats and sheep and the women and children took responsibility for their day-to-day care. The children used the donkeys to fetch water from the wells and to pull small carts loaned by neighbours to transport manure and compost from the compound to the fields. The family would also loan the donkeys for transport to nearby villages. The cow was entrusted to a local Fulani to be managed with a larger herd. Salifou Hamani hoped that it could be sold for a profit in 1999. He claimed that he would like to build up a stock of sheep and goats, but was constrained by limited finances. The small-stock would give maximum returns because they would not engage much labour; his wives and children would care for them, and they could be corralled on the fields at night to improve the colour of the soil, and, he believed, they were better for his sandy soil than cattle. He claimed that he knew nothing about cows, that they were expensive and that he would see no contribution to his soil fertility from them.

The manure from the household livestock was transported and distributed on the nearest field by his children. The farmer estimated that 30% of the field had received manure in this way during preparation in February 1998. Unable to manure the other fields in this way, the only other soil fertility improvement strategies he used on a regular basis, apart from fallow, were to mulch crop residues that were not collected for fodder and to lay millet stalks over half of each field. He was unable to consider large scale burning because the bushes never grew large enough and he thought that the wind would blow away the ash before the rains came. He did however burn the stumps of the bushes that were cut back on the *botogo* patch of his closest field during better rainfall years. This clearing method saved him time when there were other demands on labour and was safe once the first winds had passed. If not blown away, the ash would be washed straight into the soil.

During the beginning of the 1998 agricultural season, a Fulani cattle herd, which was moving northward for the rainy season, passed over his closest field on the way to the village well, grazing the fallow bushes and young weeds and leaving dung, which he referred to as a gift. In addition, an informal manure arrangement was made with the Fulani farmer who cared for his cow. Through this arrangement, some of the Fulani small-stock grazed the fallow area on the largest field during the day for two months. This arrangement cost Salifou Hamani 8000 f CFA. Although this informal manure contract was expensive, he considered it essential household spending to maintain his yields. He had decided that the fallow area would be cleared for cultivation in 1999, and predicted that the improved soil would produce a good harvest.

However, alongside these new opportunities, the family also experienced some new constraints. It was frequently short of money and food because of tax demands in November 1997. It had sold some harvest for a low price to pay the tax, but was then forced to buy extra millet, maize and cassava at higher prices during the dry season. Kinship obligations meant that Salifou Hamani had to pay for his brother's trial in a neighbouring district, and give gifts of millet to his extended family. He also gambled on a friend's business venture in the hope that the loan would be repaid with interest, but the plan failed and he did not make any profit. The family had to pay additional costs for religious festivals; Ramadan and Tabaski required extra money and livestock to be slaughtered for the festivities. A family baptism required further money and the gift of a goat.

To subsidise these costs, Salifou Hamani sought the help of family for cash loans. The supervision of village transport to the local markets made further small contribution, his first wife also sold a sheep at a profit in April. As the household food stores dwindled, she went to Niamey to ask her family for credit and his second wife gathered fallow plants to sell for cooking. He claimed that he would never consider long-term migrant work to meet the household and farm costs because of his obligations to his family in the village, whom he would leave alone if he were to work away from home. His son was not yet old enough to be in charge of the farm.

However, Salifou Hamani did practice off-farm business activities in the form of petty local trading. He had built up a network of clients and merchants over a period of years. He had borrowed money from a friend and had taken a bush-taxi to Niamey market to buy a cheap stock of cigarettes, and to Hamdallayé market to buy kola nuts, which he had intended to sell for profit in Dantchiandou and Fandou Béri. With this profit he would buy salt, spices, and seed for planting. However, the venture failed in 1998, for in May disaster struck the household when the family compound was destroyed by an accidental fire. He lost his entire trading stock and most of the remaining seed for planting. The 'Sous-Prefet' (local government) provided some financial compensation to the family to buy the materials to rebuild their home.

When the first rains of 1998 arrived in Fandou Béri in May, Salifou chose not to rush his family out to the fields to plant the precious little grain he had left. He planted millet seed and cowpeas on the nearest *tassi* field on the 15th May, after the third rainfall event. The children helped out with the sowing and the women helped indirectly by carrying seed and providing food. As the rainfall events were frequent, he continued to plant millet on the other fields, at a spacing of 1m by 1m. He planted millet grain that took 120 days to reach maturity, because he said experience had taught him that local varieties produced the highest yields. At the end of May, he began hoeing the weeds from around the young seedlings.

A month later he planted sorghum around the burnt bush stumps on the *botogo* area of his closest field at a spacing of half a metre and hibiscus near the border; his wife planted groundnut in an small part of the fallow for her own profit. He said he wished that he could dig a well on his closest field because then the crops would have been supplied with guaranteed water and his family would have a good harvest. At the end of June, he organised additional 'invitational' labour to help with the increasing task of weeding the fields and the thinning of the young crops. He was in a strong position to organise a labour exchange because he had access to the labour in both of his wives' families. In addition, the sons of friends to whom he had lent credit during the dry-season worked on the fields during the mornings.

The family's fortunes improved later in the season, with further credit from his family and from money earned when Salifou Hamani worked as a causal labourer on other people's farms. In total, he worked about thirty days in this way during the rainy season. With the extra money, he decided to pay local boys to help with further weeding in July. He organised seven or eight boys to work on the field for a few days and, in addition, provided lunch. This proved invaluable to a family like Salifou Hamani's because their low availability of labour (0.3 family labour units to 1 ha) would have made it impossible to maintain the area that had been planted, and could have resulted in large areas being abandoned to fallow. The pattern of labour response to rainfall is shown in figure 6.28 and the composition of the labour force in figure 6.29.

Although the household owed several thousand CFA, Salifou Hamani was optimistic about repaying the debts. He estimated that the household needed 200 bottes of millet for subsistence through the dry season and that the surplus would be sold for profit. Luckily good rainfall continued through 1998 and the village experienced a better harvest. He remarked that his ideal farm management strategy in the long-term was more intensive care of the land as his son grew up, using small-stock and organic manures and perhaps some purchased inorganic fertiliser. The family's vision of optimal farm management was clearly coloured by their limited capital and human resources. Salifou Hamani was not a prominent member of the community, yet even his family had coped with repeated failed harvests and stressful times by regular small-scale and local diversification of activities beyond farming. Clearly Salifou Hamani and his family were creative in their responses and had access to vital social assets (a support network).

*Figure 6.28: Household farm labour and rainfall in 1998(*see note at end of case studies)*

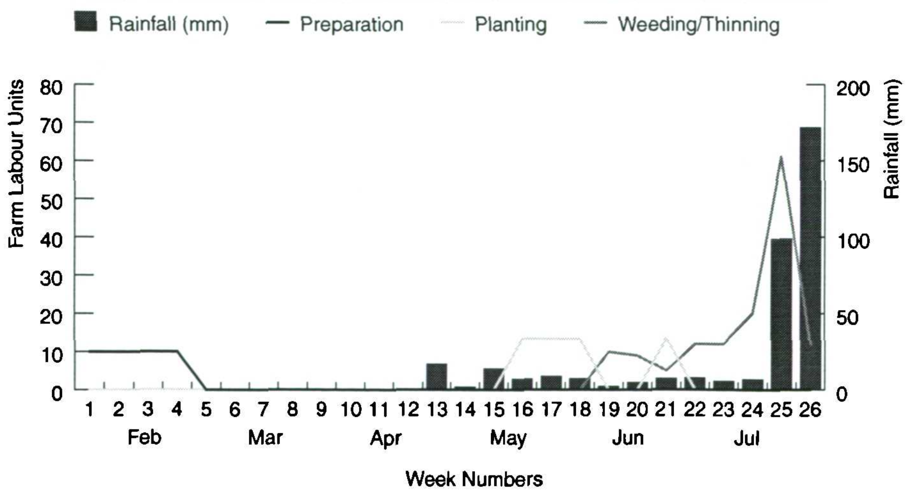
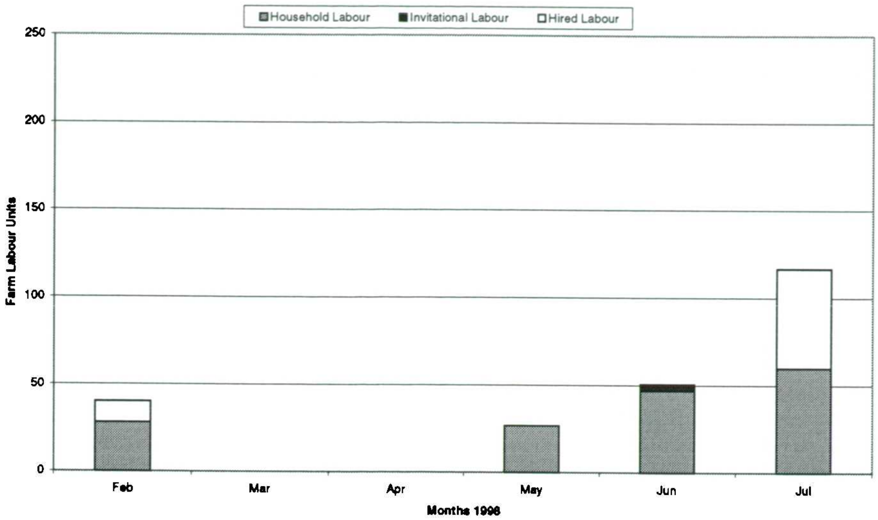


*Figure 6.29: The composition of household, invitational and hired labour in 1998**



Case Study 2

The situation was quite different for Oumarou Moussa. In 1998, he was head of a household of ten members and occasionally up to fifteen when family came to stay. He had two wives, six young daughters and four sons. Although his sons were under 15 years old, two were able to make a substantial contribution to the farm work and the future of his workforce was promising. He had six household labour units available to work the farm. He even hoped to have more sons.

Oumarou Moussa inherited only two of the six fields that he was using in 1998. These were fragments of larger fields belonging to his father, which had been subdivided between his brothers on his father's death. They added up to 6 ha (4.1 and 1.9 ha). By 1997, he had obtained three additional fields through the informal process of land loans (borrowing a field from a neighbour on credit or by giving a percentage of the harvest). This process gave him access to another three fields, and although the fields were small 'in-fields' (1.9, 0.2 and 0.3 ha) they brought the total holding to 8.4 ha. During 1998, Oumarou Moussa was still acquiring land, hiring another field to the south-west of the village. The acquisition of this large 13.2 ha field brought his total holding in 1998 to 21.6 ha, the largest cultivated farm area in the sample. However, even with the available labour, the size of the farm meant that the labour intensity per hectare was only 0.3. Of the two fields that he owned, the smaller was close to the village (0.5 km) and the larger was 3 km away. The small fields that he had borrowed were also all relatively close at 0.2, 0.3 and 1.6 km. However, the largest borrowed field was over 4 km away. The fields were scattered over the village territory making labour use inefficient, but the success with which he was able to maintain the land loans was testament to his skill and his ability to mediate access to resources.

As well as the large farm, the family also had a number of livestock. At the start of the rainy season, the women in the household owned ten small ruminants and Oumarou Moussa owned five cattle. Although some of the stock was entrusted to local Fulani for breeding, they remained the family's principal form of liquid asset. Oumarou Moussa's first wife doubled her money on an investment in some sheep when she sold them in April. The household said they would like to invest in more cattle as security against losing land and more small-stock for their preferred manure and ease of management. Oumarou Moussa used his cattle in the late dry season for draught power in ploughing, although the hire of the equipment was expensive. He was the only farmer in the study to use this practice. Surprisingly the household did not own any donkeys although they could be borrowed if necessary.

Despite the evident advantages in livestock that Oumarou Moussa had compared to Salifou Hamani, much of Oumarou Moussa's farmland had poor soils. The entire farm consisted of *tassi* soils in different stages of nutrient depletion, specifically the borrowed fields close to the village. He maintained soil fertility by mulching the surface to protect it from the wind and to encourage slower infiltration. He claimed that the best soils were on his own village-field because it was large enough to put into fallow rotation and had developed a *korobanda* crust. Here a 3-year fallow covered over 20% of the field. His own 'in-field' had approximately one third in 2-year fallow. He had not considered fallowing the borrowed fields because he was afraid that this would cause conflict with the owner. Consequently, although already in poor quality, the borrowed land was never rested and striga was common. The lack of bush vegetation on the larger borrowed field also meant that he was unable to burn it. He was not concerned by this lack of fallow rotation because he hoped to loan another field in 1999 and had received a 'gift' of manure on his own field.

The intricacies of managing a large highly fragmented holding, such as Oumarou Moussa's, demand a high level of skill. As Netting (1993) has argued, family labour on such a holding is intrinsically superior to hired or co-operative labour because supervision is embedded within the social interaction of the household. Oumarou Moussa was able to rapid response to the rains, with the whole family involved in the sowing of a large area in a short time. Figures 6.30 and 6.31 show a different pattern of labour management from the first case study, the difference being a result of different demographic structure and endowments. The women in Oumarou Moussa's household were not expected to undertake any work in the fields except during sowing or for cash-crop harvest. The business of sowing was a time-consuming exercise for the household and it relied on invitational labour (by male relatives) to begin the weeding work while the family was still sowing part of the farm. Oumarou Moussa also employed four boys to help later in the season.

Oumarou Moussa intercropped short-growing millet varieties and cowpea on the borrowed fields. He planned to sell the cowpea harvest but to retain the millet as the family's subsistence staple. On his closest owned field he planted millet but also groundnut and hibiscus (on the borders) to sell. He claimed that this land was unable to support sorghum. The millet was planted in pockets at 1.50 - 1.45 m apart; he believed that this was the most profitable distance on low fertility soils. However, he used the soil's natural micro-diversity and planted the better patches on his own fields at a 1 - 1 m density.

The most significant difference between this household and the previous example was its ability to maintain itself almost exclusively by farming. The avoidance of off-farm and business activities was a consequence of the family's capacity to use its access to land and labour to buffer itself from risk and poverty. Only in times of exceptional harvest failure, as in 1997, did Oumarou Moussa resort to a small income from fees for religious duties in Niamey. He used this income to buy extra millet. He believed that in the future his sons could learn a trade or work in a city to support the family, if ever the rains were bad. Oumarou Moussa was as a reasonably influential character in the village. He was spokesman for *La Jeunesse* (Association of Young People) as the 'Leader of Young People' in Fandou Béri. His situation suggests that productive capacity is related to endowment in family labour.

Oumarou Moussa did not know whether he would always be able to borrow land. There is evidence of increasing resistance to alienating family land in long-term land loans, even if it not used and even if to neighbours. It is especially difficult if the harvest from the borrowed field is not for self-sufficiency. Oumarou Moussa must retain a favourable land-to-labour ratio to be self-sufficient yet manage different fields and a different-sized farm every few years. He believed that if he could afford inorganic fertiliser then he could run just a small farm. He also indicated that without the commitments of managing a large farm, he would like to pursue a business.

*Figure 6.30: Household farm labour and rainfall in 1998**

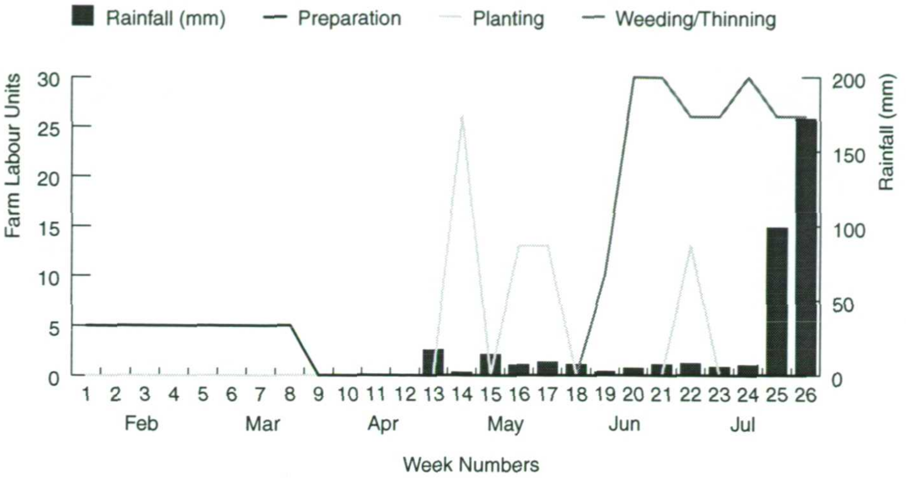
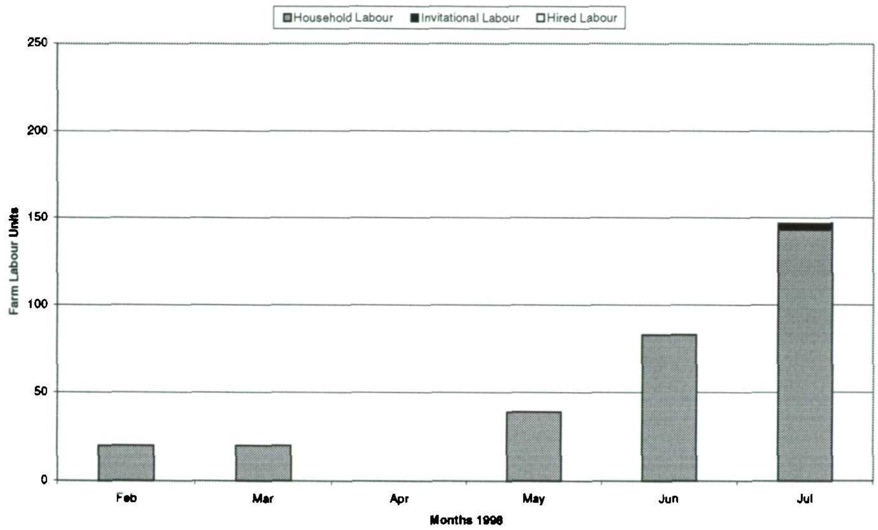


*Figure 6.31: The composition of household, invitational and hired labour in 1998**



Case Study 3

In 1998, Soumana Adamou had a large family, like Oumarou Moussa, with 14 household members. He also often had extended family members to stay. He had eight children with two wives. However, the household demography was quite different to Oumarou Moussa's younger family. His eldest son had his own family. Many surveys would consider them a separate household, even if the son's role were pivotal to his parent's situation as it was here. Together with his two younger brothers, the son helped his father on the family farm. They farmed family fields, as well as other fields, which they had received as gifts. Soumana Adamou had available five labour units and this was likely to grow over time with the help from grandchildren. The family was in a strong position in regard to future labour.

In addition to the large labour force, the family had access to sufficient land. In 1998, Soumana Adamou and his son cultivated farmland totalling 5.4 ha, although the total of land they owned was much larger, incorporating two bush fields and two further fields, but these were loaned out. Of the four fields that Soumana Adamou was cultivating in 1998, none was close to the village, being situated in the village and out-field zones. The largest field was 3 ha and nearly 4 km away from the compound. The others were smaller (1.1, 1 and 0.3 ha) and at a distance of 2.6, 2.8 and 3.9 km respectively. For the whole of the cultivated farm, the labour-to-land intensity was 0.9, which is a much higher ratio than in the previous two examples.

Soumana Adamou regularly undertook long-distance migrant work during the dry season, trading and taking fees for religious duties. He had family and friends in the Ivory Coast and chose to return to these each year to accumulate capital, coming home just before the rains to prepare the farm. The money was used to meet domestic costs, buy extra food for the family and, most significantly, to invest in livestock. Soumana Adamou considered livestock breeding a sensible investment for the future. He had accumulated a large stock and believed that they were an essential security against his farm and old age because they could be liquidated for profit if necessary.

Although a local Fulani agro-pastoralist cared for his cattle, the women in the household retained most of the animals (goats and sheep) for sale. For example, his first wife sold a sheep in Wankana market in April 1998 to buy household goods and she invested the remaining profits in another sheep. The women in the household tended to contribute to domestic gain rather than to the work of the farm. In total, the household owned 32 cattle and 70 small ruminants, making them wealthy and contributing to Soumana Adamou's status as a religious advisor. The household also had four donkeys that were used for transport, often with a cart.

Soumana Adamou's farmland was of mixed quality. The nearest *tassi* field was considered to have the best soil because Soumana Adamou had arranged a manure contract for this field with the Fulani who managed his livestock. At the end of the harvest, the Fulani grazed his animals on the crop residues over a six-week period for a 2500 f CFA fee. Soumana Adamou believed that the largest 3 ha field had the worst soil, although it had been managed in fallow rotation. Yields had dropped to less than one quarter of their value since the field was first cultivated. He believed that this reduction was the result of declining soil quality because of eight years continuous cultivation with little input of manure. Although the existing fallowed area was over four years old, he had decided to put the total field into fallow for at least three years. He said that it would not become a long-term bush field because he would use the land again soon. Even in fallow, the land would remain profitable for firewood collection and rangeland. To compensate for the loss of the largest field, he planned to take back a field at the end of the year (November 1998) which he had loaned to another farmer. He would use this field as a place to corrall his animals over the dry season and cultivate it in 1999. He believed that he had a right to do this because he was the owner of the land, and as he only planned to rest the large field for three years, the tenant would be granted temporary rights again afterwards.

Soumana Adamou's two smallest fields had good soil quality; one was *tassi* with *korabanda* patches, approximately 10% of which was in a 4-year-old fallow, and the other contained areas of *gangani* that produced a better harvest during high rainfall years. Corralled animals had manured about 20% of the *tassi* field. Soumana Adamou did not burn the fields because he felt that there was not enough biomass to make it necessary or profitable, but should he need to clear a large area of bush in the future he would cut the bushes and practice slow burning. When small areas of fallow were cleared, most of the cut bushes were taken home as fodder for tethered animals or used as firewood.

The decision to undertake migrant work had brought the household advantages, but also disadvantages in the new agricultural season (1998). The late return of the household head, who alone could make decisions for the farm, resulted in the late preparation of the *botogo* area. The late preparation work can be seen in the labour response to the rains in figures 6.32 and 6.33. The family labour was focused on preparing and sowing the *tassi* at the expense of other areas. Soumana Adamou claimed that he had not been expecting a year with better rainfall and had not thought that it would be necessary to clear the soils reserved for more demanding crops. The *Guiera senegalensis* bushes had re-grown and needed to be cut back.

The household income from migrant work was used to buy extra seed. A variety of local varieties were planted (selected from the 1997 harvest), which Soumana Adamou preferred because they were hardier during in-season droughts. Later he also planted 'Red Millet', which meant he was able to stagger the harvest and maintain a smooth labour return. Millet was sown on all the fields and was intercropped with cowpea on the *tassi* areas during the seconded sowing. On these *tassi* soils Soumana Adamou also planted hibiscus around the borders as a cash crop. On the nearest field, the manured area was planted with sorghum and sesame. It was the first year he had tried to grow sesame on the farm and thought that the application of additional manure to this crop would provide good growth. To prevent any land becoming abandoned to fallow through weed competition, a group of boys from the village was paid to work on his farm, with labour peaking near 60 units.

The accumulative endowments of land, labour and capital for this household protected it from severe food shortages. However, the decision of the household head to practice migrant work remained a difficult balancing act between the desire to invest for security and the demands of the farm. At the time of the study, discussion with the household suggested that it saw its future wealth coming from livestock investment rather than from farmland, which would be used simply for self-sufficiency. This apparently did not mean an increased intensification in farm management and should the household have increased demands, Soumana Adamou believed his sons would have to make sacrifices and work away from the farm as he had done.

*Figure 6.32: Household farm labour and rainfall in 1998**

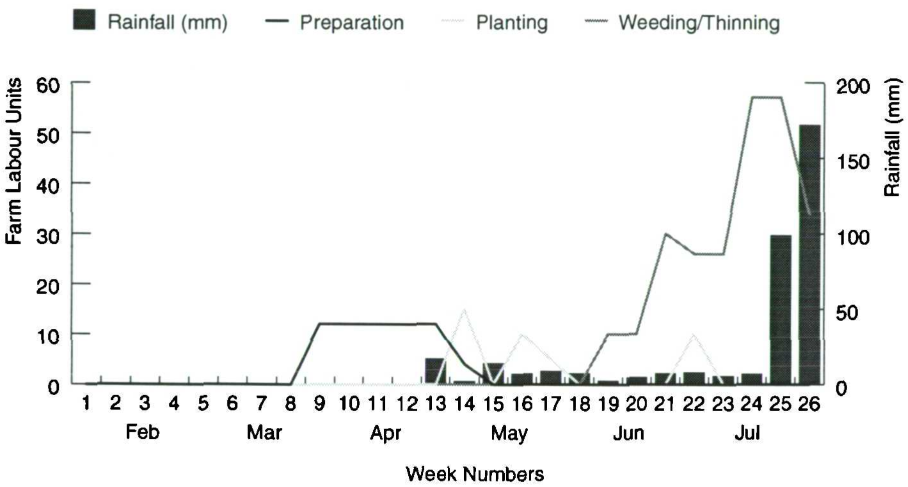
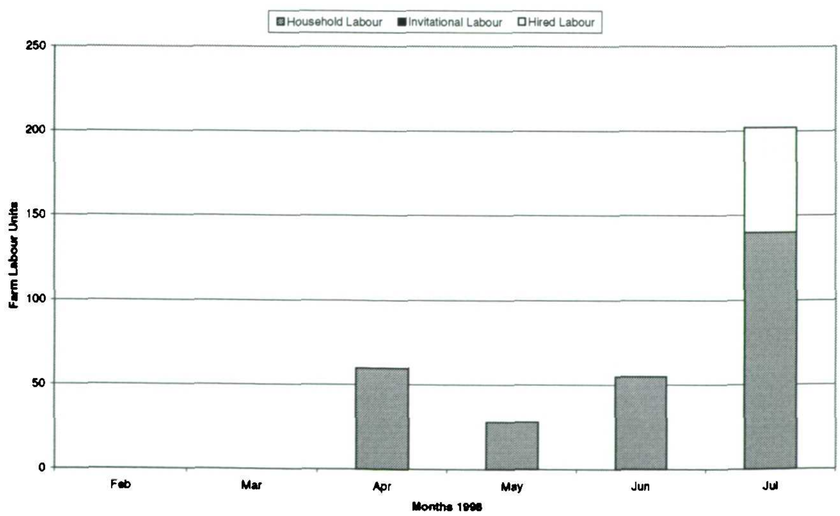


*Figure 6.33: The composition of household, invitational and hired labour in 1998**



Case Study 4

Fulani agro-pastoralists have only settled recently in the village. Amadou Soumana has been settled for 14 years on land pledged to him by an important marabout, and he farms it in return for 'a gift from the harvest'. Amadou Soumana lives on the field with his wife who is 50 years old. He is an elderly man himself (he knows he is over 65 years) and, although he has several sons by his first marriage, only one works on the farm full-time. His eldest son was herding cattle in the parklands of SE Niger during early 1998. His second son frequently left the household from October to May to attend a Koranic School in Danchiandou, on the advice of his father. He was not present in the village during the time of the study and his father was not sure where he was. His third son was 21 and also undertook pastoral activities with relatives during the dry season. His fourth son was 14 and remained on the farm to help his father with the livestock and farming work. He also had a six-year-old boy and a baby girl who was very ill. Although he had a large family, the size of the family unit that remained in the village during the agricultural season was small, and only three labour units were available to him.

The farm was 6.4 ha in size and was in one piece. About 4.5 ha were under cultivation in any one year. With the given labour units, the household had a 0.5 labour intensity.

Amadou Soumana had an interest and knowledge in livestock rearing that was a beyond all the Djerma farmers in the study. He controlled a livestock herd of 24 cattle and 41 goats and sheep, although the household total was higher as his son controlled another herd. The household also kept a number of fowl. Ownership of the livestock was dispersed through the household; his wife and children owned 7 cows, 13 goats and 12 sheep. In addition, he looked after eight cows belonging to Djerma in the village (buying millet husks in the dry season) in return for their products.

When the rains arrived, the animals were moved to rangeland where they grazed the young grasses. In the evenings during this season, the herd was corralled on fallow land in the village and at night moved closer to the home. Amadou Soumana indicated that the compound hut had not always stood in the same location and was moved to make best use of the manure from the tethered animals at night. The one donkey owned by the household was used for transport, for example the collection of the 140 litres of water needed each day (the family lived some distance from the village well). The livestock were watered at the well itself or at neighbouring wells each morning and evening by his children. His livestock were kept near the hut at the end of the harvest to graze his fields but he also seized the opportunity to improve his capital assets by engaging in manure contracts with local Djerma.

Amadou Soumana's farm was situated on a boundary between *tassi* and *gangani* soil. He believed, as did most other farmers in the village, that his cultivated soil was of a high quality and much of it had a darker colour because the high organic input from manure and mulch. Approximately one fifth of his area was managed in fallow rotation. This fallow was a place for the animals to be corralled at night after the cowpea was sown. The fallow area was two years old in 1998. In the same year, Amadou Soumana cut back re-growth on bushes and burned approximately 20% of the woody stumps in the fallow area to lower the risk of pest attack.

Despite the household's endowment of livestock, and its ability to maintain high quality soils and the plentiful rainfall in 1998, the agricultural season became harder for Amadou Soumana. The instability of the household labour force meant that he was constantly struggling with labour shortages and was forced to work long hours on the farm. Consequently, much of his field had not been prepared before the first rains and he had to begin seeding while still needing to carry out other tasks (see figures 6.34 and 6.35). He intercropped millet (the 100 day-growing variety) and cowpea, which was planted three weeks later than the millet along with hibiscus on the border of the field. The hibiscus would be sold. During June and July, he became sick and to maintain farm work, he paid local boys to help with the second weeding. Even with his duty as religious advisor for the Fulani, and his involvement in negotiations between Djerma and Fulani through the chief, he had to give a gift from the harvest each year to the chief, as a token of his permission to live in Fandou Béri.

*Figure 6.34: Household farm labour and rainfall in 1998**

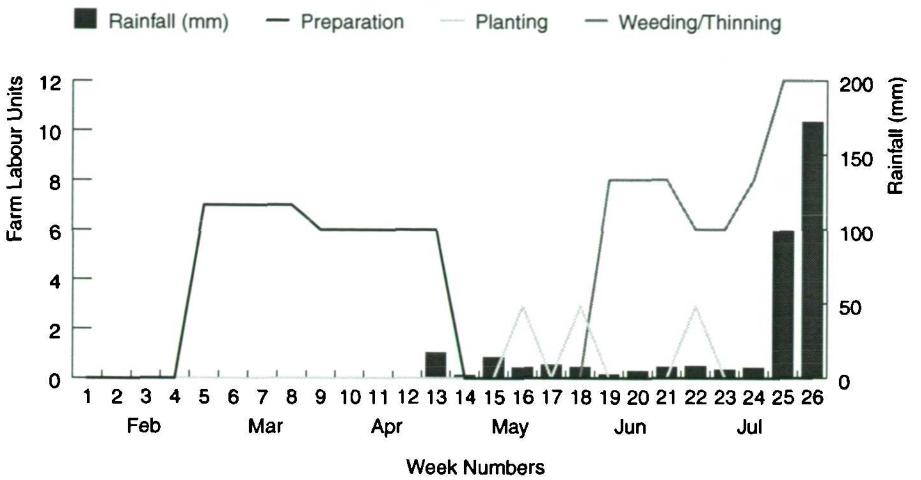
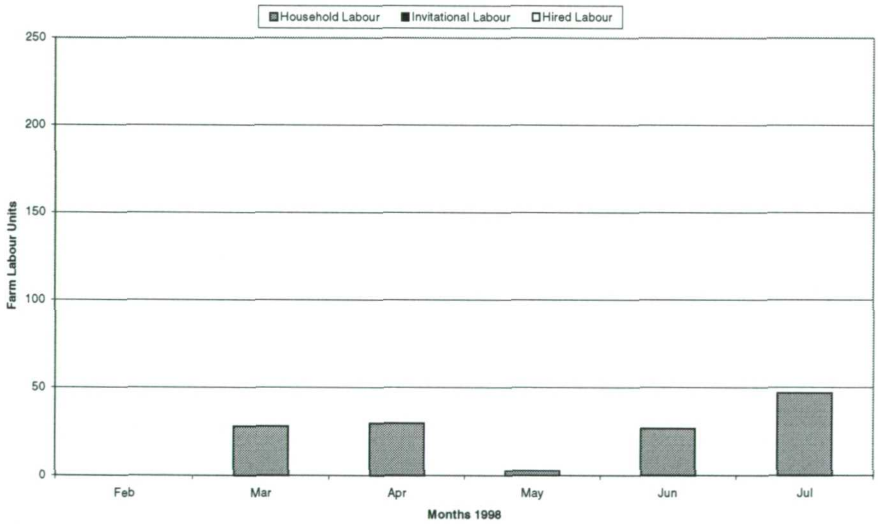


*Figure 6.35: The composition of household, invitational and hired labour in 1998**



This case study contrasts with the previous examples and underlines the vulnerability of a small household to any disruption in its limited labour supply. However, Adamou Soumana's endowment of livestock differentiated him markedly from his Djerma neighbours. The key vulnerabilities of the Fulani are the condition and breeding capability of their livestock, the size of the herd, and the family's integration into the social fabric of settled village. Adamou Soumana's experience and knowledge of livestock rearing had given him and his family a role in the village. However, it was the household's ability to sell several animals at local markets (Wankana, Hamdallayé and Fandou Béri) during food shortages that was critical to their coping strategy. Although they bought livestock at the end of each season, the family sold their only bull in February 1998, a sheep in March, two goats in April for the festivals, two goats and a sheep in May and a goat and a sheep in June. Despite the livestock trading, the family also remained reliant on the supplementary income from the women. Adamou Soumana's wife sold 'galettes' she cooked at home, spices grown on her own plot of land, but mostly livestock products such as butter, milk and sour milk to customers in the village. With any money the women earned, the household bought food.

Most significantly, Amadou Soumana's stock enabled him to practice intensive mixed farming, maintaining an average productivity of the field at 445 kg/ha/yr. He would not be able to maintain such productivity without the animals, given his low labour endowment, and this is despite the expensive veterinary costs (vaccinations in February) and the labour demands of the stock. He remained optimistic about the future for the farm and for his retirement. He believed that the area could support more animals and the constraints on his assets were only financial. However, his son disagreed and had stayed away from the Fandou Béri region because of a lack of pastures. He had remained in the Azawak region since he left home.

Case Study 5

Garba Amadou and his wife were not prominent members of the community in 1998 although they were born in Fandou Béri. They had been married for 23 years. The household had 12 members in 1998, five sons (aged 22, 18, 15, 13 and 8), three daughters (aged 16, 12 and 5) and elderly close relatives. Garba Amadou was able to mobilise 7 labour units to work the family farm. The older sons could be considered a separate household, but because they cultivated the farm with their father, they are considered as one here.

In 1998, the 7.4 ha farm consisted of three inherited fields: an 'in-field' (1 km from the compound) of 1.7 ha, and two 'village-fields' (both at a distance of 3 km), 4.6 and 1.1 ha in size. The smaller fields had *tassi* soils and the largest was *gangani*. With plenty of labour, the family could farm with a high labour-to-land intensity of 1.0.

Their soils were not especially fertile; the family rated the closest field as exceptionally poor, and left most of it in fallow. 20% of this three-year fallow was cut and burnt during preparation in early 1998. The family received a 'gift' of manure from the farmer's nephew and this was used to manure about 40% of the cultivated area of this field. Apart from mulching and laying branches on the soil to prevent erosion, there was little Garba Amadou claimed to be able to afford to improve the soil fertility. The household owned only five small ruminants at the beginning of 1998. Garba Amadou would have liked to have corralled animals on the fields, but did not own enough animals nor was he able to pay the costs for local Fulani in a manure contract. He claimed to be dependent on gifts from extended family and friends.

The inability of the household to sustain fertility, other than by fallow rotation, meant that they were at the mercy of the rains. The family had the lowest average annual income for the study sample and Garba Amadou said that he felt that because he was unable to maintain soil fertility and therefore crop yields, he was forced into long-term economic diversification. He foresaw difficulties for his sons in the future (with the farm) and was actively encouraging them to learn a trade or make business links. His eldest son was training to be a marabout in Nigeria and he was practising petty trade while away. The second son travelled to the Ivory Coast with his father each December. He remained there until April, trading in local cloth while his father came back to begin farm preparations in January. The third son had an apprenticeship with Nigerlec in Niamey.

The profits they made individually were shared between the family members and proved a relatively effective measure to counter food shortages. However, they still regularly relied on support from relatives. Other measures included the sale of wood and dried fodder, hibiscus, groundnuts and grass mats at the village market. His wife carried out many of these activities on his behalf while he was working away from home. The money that she made was spent on the farm. She also sold some of her sheep at market to pay for maize and millet, which were needed in February and again in March and June. In February, his wife had a baby and the family received gifts from the rest of the village at the baptism.

When the rains arrived in 1998, Garba Amadou chose a two-planting strategy for his crops (figures 6.36 and 6.37). He and his sons planted millet (a local variety with a 110 day-growing period and Red Millet) at a similar density over all the fields (1m by 1m). They planted the closest *tassi* fields first. Cowpea was intercropped on the *tassi* at 1.2m intervals and sesame was planted on *gangani* patches on the village-fields. On the *gangani* field, he additionally planted sorghum at 0.8m intervals and hibiscus as a border. Apart from the cropped staples, which the family would keep, he was hoping to sell the extra crops. Despite the capacity of the *gangani* field to support a greater diversity of crops, the family claimed that yields had dropped so low in recent years, that along with the high occurrence of weeds, they would be forced to put the whole field in fallow for the next year. Garba Amadou was convinced that this would not cause conflict because he believed his neighbours knew that the land belonged to him and would not ask to cultivate it.

Figure 6.36: Household farm labour and rainfall in 1998*

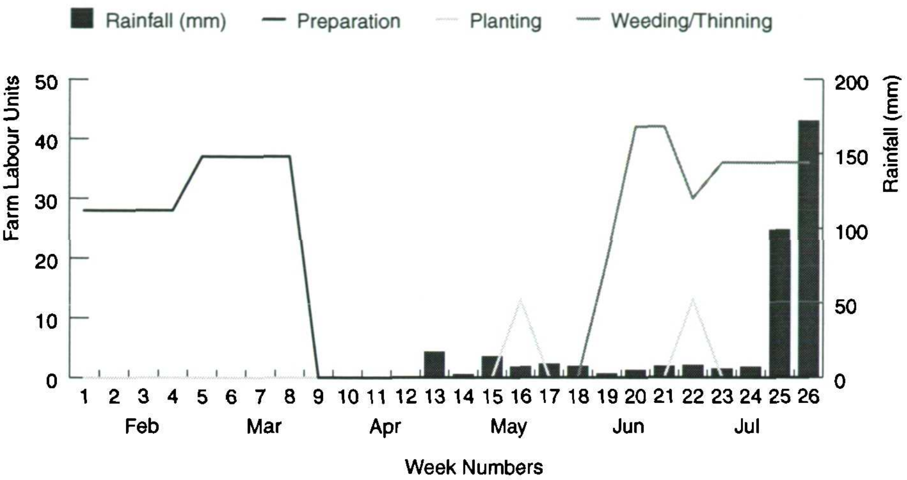
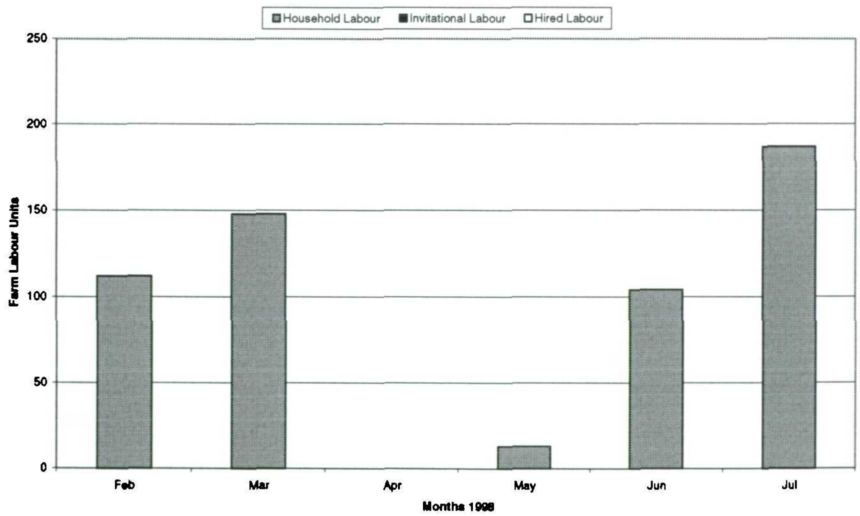


*Figure 6.37: The composition of household, invitational and hired labour in 1998**



Case Study 6

In 1998, Abdou Idé (aged 44) lived with his current wife (aged 26), two sons (aged 19 and 13) and four daughters (aged 16, 14, 10 and 8). The total household had 8 members but he claimed that the small supply of labour constrained all his activities and indeed the family had only 4 available labour units.

The farm was fragmented into two fields, both inherited, and was the smallest in the sample at 2.8 ha. The larger field (1.5 ha) was closest to the village (1.5 km) and had *tassi* soil. The field had over half a hectare in fallow (3 years old), where the children grazed the small ruminants during the day. The other field was 1.3 ha and nearly 3 km away. Most of this field was *gangani*, on high ground with little vegetation and bordered by a few isolated trees on one side and on the other by the track leading from the village to the north of the territory. The small size of the farm meant that Abdou Idé was able to maintain a high labour-to-land intensity of 1.4, making the farm the most productive in the study. This case study indicates how only considering a household's endowment in land can be misleading as an indicator of how well a household is able to cope.

The family owned one cow, which was entrusted to Fulani, and six small-stock. Abdou Idé did not transport the manure to the fields because he claimed that it was too difficult to carry without a donkey and that it was easier occasionally to corrall the animals instead. With cash from crop sales at the end of the 1997 harvest, Abdou Idé was able to pay for a contract with local Fulani for manure exchange on his *tassi* field. This cost 9000 f CFA for 2 months.

In 1998, the *tassi* field was planted with millet (before the *gangani* field) but both fields had been prepared in time for the rains. With assistance from his sons, Abdou Idé planted a short-maturing variety of millet on his fields. The micro-variability of the soil did not greatly affect his choice of planting density. Cowpea was intercropped on both fields and hibiscus was planted on the border of the *gangani* field. The labour response to rainfall is represented in figures 6.38 and 6.39.

*Figure 6.38: Household farm labour and rainfall in 1998**

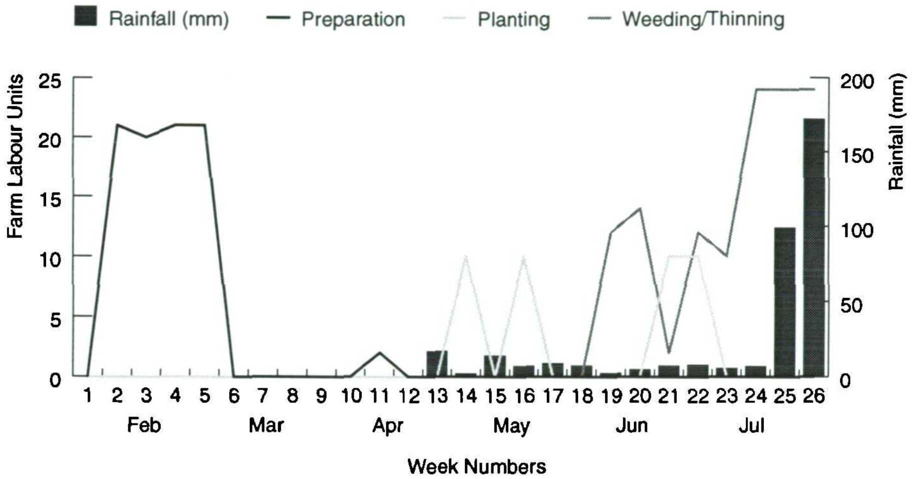
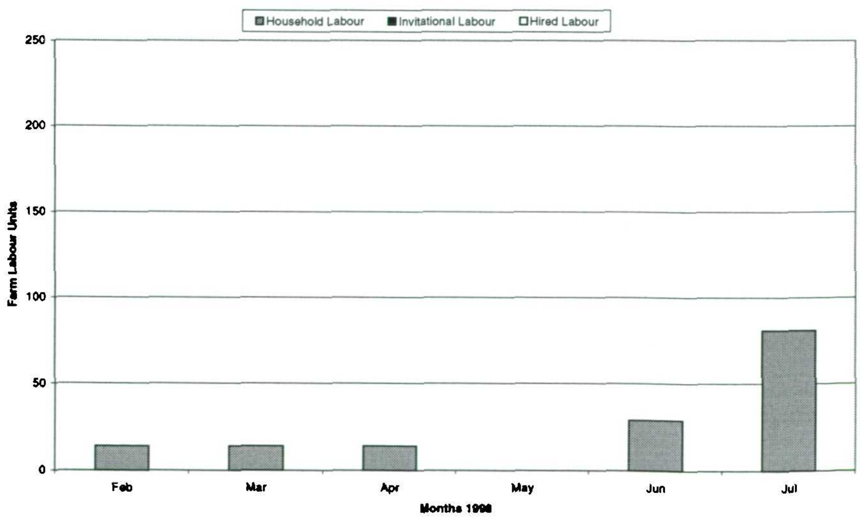


*Figure 6.39: The composition of household, invitational and hired labour in 1998**



Despite the evident productivity of the farm and Abdou Idé's capacity to sell some crops to finance his operations, the small size of the holding made it difficult to accumulate savings from agriculture alone. Thus, the family had diversified into several off-farm income-generating activities. Most significantly, Abdou Idé practised annual migration to pay for food at the start of the agricultural season when the grain stores are empty. He travelled to the Ivory Coast to sell clothes and his sons practised petty trading. He also worked on other people's farms during the agricultural season, made building bricks to sell and cut wood from his fallow land to sell in Niamey. His wife sold andropogon grass mats, groundnuts, sesame and hay at local markets. She also sold a sheep and some goats to buy maize for the family. As a result of these activities, the household managed a higher income than would be expected from their assets.

Case study 7

Djibo Abdoullaye is an elderly Djerma (aged 70) who lives with his two wives, offspring and extended family. He planned to retire soon to a small plot on the farm, but in the meantime remained the head of a household of ten (labour unit of 5), and still worked on the farm. His 30-year old eldest son now managed most of the day-to-day work on the farm, with the help of his brothers, aged 20 and 16.

The farm consisted of four fragmented areas, totalling 5.7 ha, and incorporated all the soil types in the village. It includes an area of bushland. The largest field Djibo Abdoullaye owned, which he chose to farm in 1998, was a 2 ha field with *botogo* and *gangani* soils, 4 km walk from his compound. He considered this field very fertile under a good rainfall regime. A strip of 3-year old fallow remained uncultivated along the border of this field. He said that this fallow would be cleared in 1999.

Djibo Abdoullaye had been farming a large *tassi* field (3.5 ha), 0.9 km from the village, but he had borrowed the land, and just before the 1998 season he had to return it to the owner after a disagreement over who needed the land the most. To compensate for the loss, he cleared a small patch of fallow that he owned 1 km from the village, but this *tassi* field was only 0.2 ha. He had hoped that, because newly out of fallow it would produce more than the equivalent of 0.2 ha of the older *tassi* field that had been lost.

Without a donkey to transport manure from the compound, he corralled small-stock on his fields at the end of the harvest in the hope that they would graze the crop residues. These animals belonged to his first wife and his daughters, and in May 1998 they totalled six and were usually kept tethered at the compound. The family also owned three cows, but these had been entrusted to local Fulani.

On the two fields cultivated in 1998 Djibo Abdoullaye intercropped millet (100-day variety) and cowpea (in the seconded seeding) (figures 6.40 and 6.41). He additionally planted sorghum and hibiscus on the *botogo* field because the silty soils were reputed to retain more soil moisture than the *tassi* ones.

*Figure 6.40: Household farm labour and rainfall in 1998**

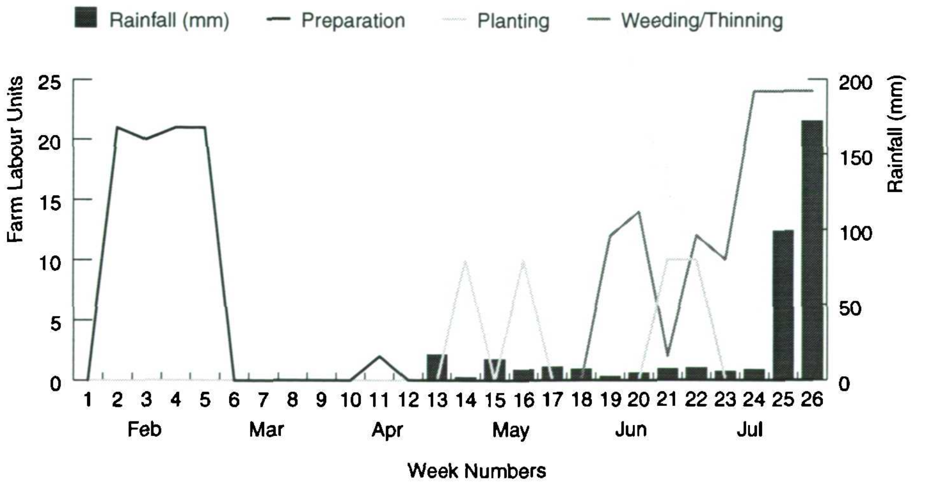
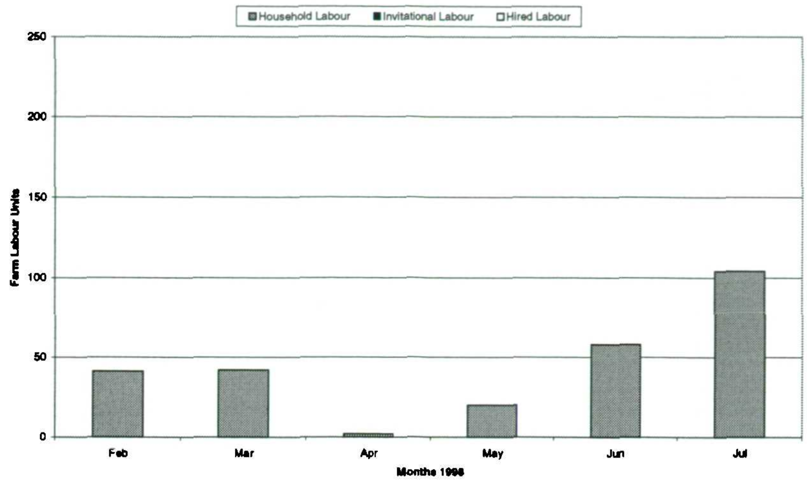


*Figure 6.41: The composition of household, invitational and hired labour in 1998**



Prima facie analysis of this household might suggest that it would be vulnerable to poverty and, like 'small households', elderly households are thought of as at a disadvantage with regard to off-farm work. However, this example was included here because it demonstrates that the situation is rarely so simple. The contribution that Djibo Abdoullaye's sons made to the farm operation was significant. The labour intensity reached 0.9 when it included the sons. They also took migrant work during the dry season, one of the sons to the Ivory Coast, the other to visit family in Niamey to collect sacks of maize and millet. The sale of their older daughter's goat helped to purchase more maize in May and religious gifts of millet (*hormone annuelle*) were made to the family by their extended family in January. With this extra information, the household can be seen as much less vulnerable. Djibo Abdoullaye considered his retirement and old age to be secure.

**Source: own data 1998. Graphs for the remaining case studies can be found in Appendix 3.*

6.3.1 What can the case studies add to the picture of differentiation?

Even though there are overall patterns of land use, as identified in the analysis of the database, the case studies show that it is still difficult to generalise about households. Likewise, although statistical groups of strategies can be identified, the case studies illustrate the importance of recognising differentiated strategies. There is no 'typical farmer'.

Furthermore, notions of diversity in land management introduce the complex and difficult subject of poverty. The case studies suggest the elusiveness of poverty as a concept in a Sahelian family, despite the prevalent use of the term 'poor households' in the literature and the ease with which it has used (frequently after statistical analysis). There are so many interrelated variables that finding simple explanations may not be appropriate.

This analysis of inter-household differentiation shows that, overall, poverty is the result of the way people are able to respond to opportunities and constraints at the local level. They themselves identify poverty as the lack of access to, or the inability to mediate access to, key resources (figure 6.42). These key resources have a direct influence on the household's 'seasonal situation' and, therefore the allocation of land to cultivation or to fallow. As indicated in figure 6.42, farmers identified these key resources as: productive land (climate, soils, vegetation), livestock, productive capacity (capital, labour, skills, tools), networks for commercial activity and the quality of grain from the last harvest. Informal networks and institutions and formal institutions and process indirectly influence the availability of these resources, and there is additionally unpredictable feedback. This unpredictable feedback includes drought, crop failure or the loss of livestock, crop attack from pests and disease, conflict and social pressures, illness or management mistakes. Many of these factors are exogenous factors. Each new season, new forms of differentiation exist in the households' situations, and in consequence, in the farmers' land use management and soil fertility investment. Considering the household's 'seasonal situation' gives some understanding of household poverty, because the concept is embedded in key resources, has a historical and social context and is located within wider economic systems.

Within the Sustainable Rural Livelihoods framework, investment and cultivation can be viewed as the result of households having the productive capacity to capitalise on their resource assets and networks. At no stage in the decision-making process can individual status, knowledge and power be divorced from the value of each asset. Social networks and power links are of paramount importance, and cannot be revealed by statistical analysis alone. The working framework and the case study analysis showed that farmers' choices about land management and investment are dependent on 'livelihood structure'. Their priorities are based on that structure, which is itself dynamic, an aspect that is difficult to appreciate with statistical analysis. However, the approaches have proved complementary and the next section provides some conclusions to diversity between farmers' land management practice in Fandou Béri.

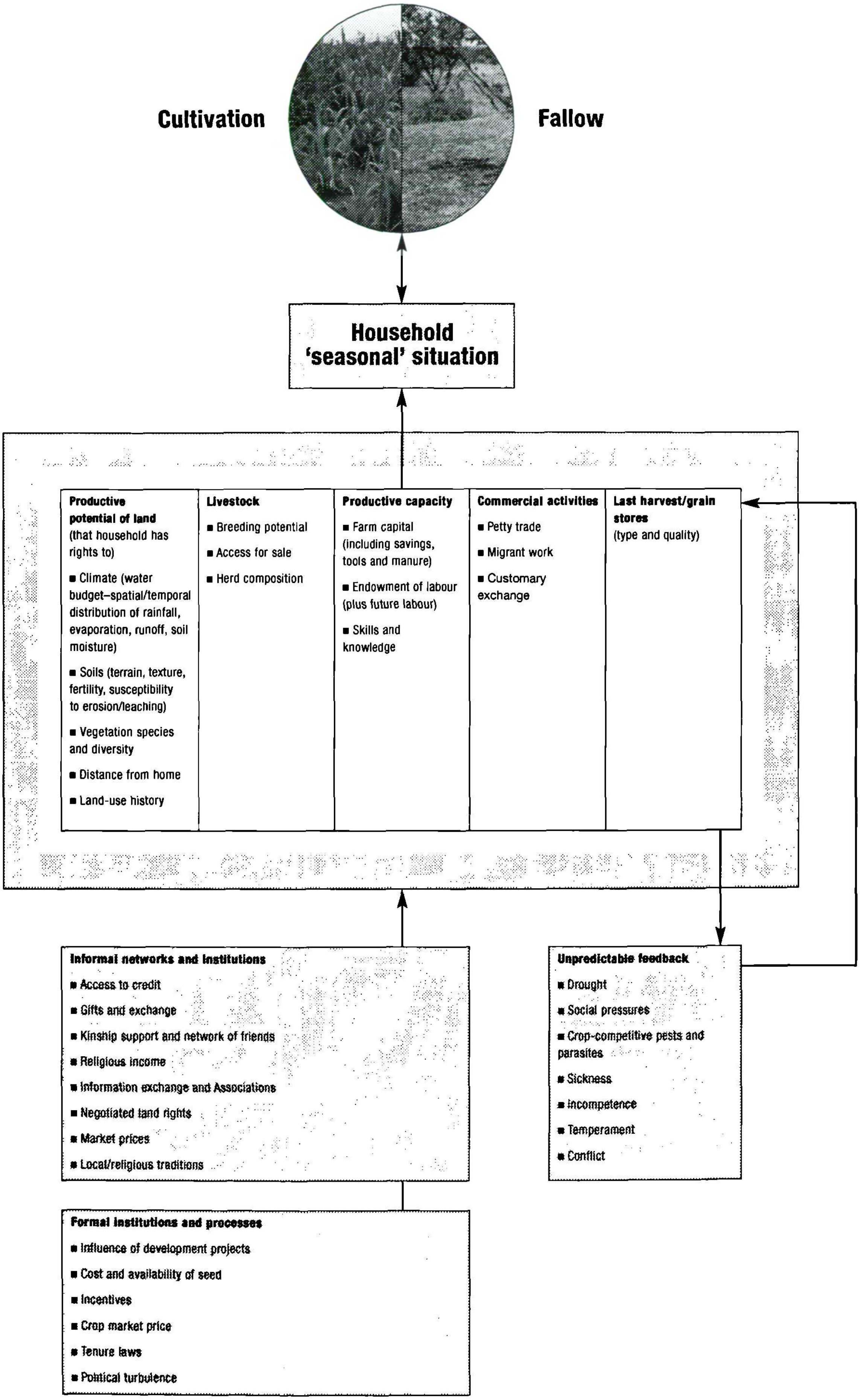


Figure 6.42: Diagram of farmer-perceived influences on land allocation

6.4 Conclusions

Inter-household analysis in this chapter has shown the patterns in farmers' land management practice in Fandou Béri, and provided some explanations for diversity.

First, the statistical analysis showed that both land type and socio-economic factors are significant in differentiating the household data. These data could group associations of farms with similar strategies, differentiated primarily by wealth and family labour and, to a lesser extent, by many other interrrelated variables. There were significant differences between Fulani and Djerma farms, but the symbiotic existence between these two groups in this village must be emphasised.

The different groups in this analysis were associated with different approaches to farm management in response to an array of perceived problems and opportunities. These differences in management are expressed in patterns of diversity that are related to local perceptions of soil quality, and these in turn are embedded in the wider agro-ecological system. This local soil categorisation is combined with a terminology for land use to create distinct zones, centred on the household, as in Sahelian villages elsewhere.

A positive relationship was found between average returns to labour and the intensity of land use within the farm but at field-scale it was found that small fields close to the village were less productive than out-fields. However, not enough is known about the patterns of nutrient mining in Fandou Béri to speculate further about relationships between soil properties and resource use. Clearly any relationship would be highly sensitive to the rainfall.

Further statistical analysis identified the key determinants of Djerma land allocation (whether land was put into cultivation or fallow, intentionally or not). These determinants were soil quality, available family labour, household wealth and the size and distribution of fields within the farm. These factors interact over different temporal and spatial scales.

The pattern of labour use is highly responsive to rainfall distribution and crop performance. Labour responsiveness to rainfall appeared consistently important throughout the analysis, being the result of household demography, access to networks and status. The contribution of women to the household, although often indirect, was found to be significant. There was a strong relationship between access to labour, household wealth, the number of small-stock and the amount of fallow. Despite the prevalence of short-fallow rotations on the lowest quality soils, these areas had the most intensive management. Fallow was shown to be a result of constraints on the farm and the absence of other methods by which to improve soil fertility. Although the statistics reflect only a snap-shot and were only of a sample from one farming community, their analysis gave an insight into why farmers made certain decisions based on their household endowments. However, statistical analysis of the data nevertheless cannot tell the whole story.

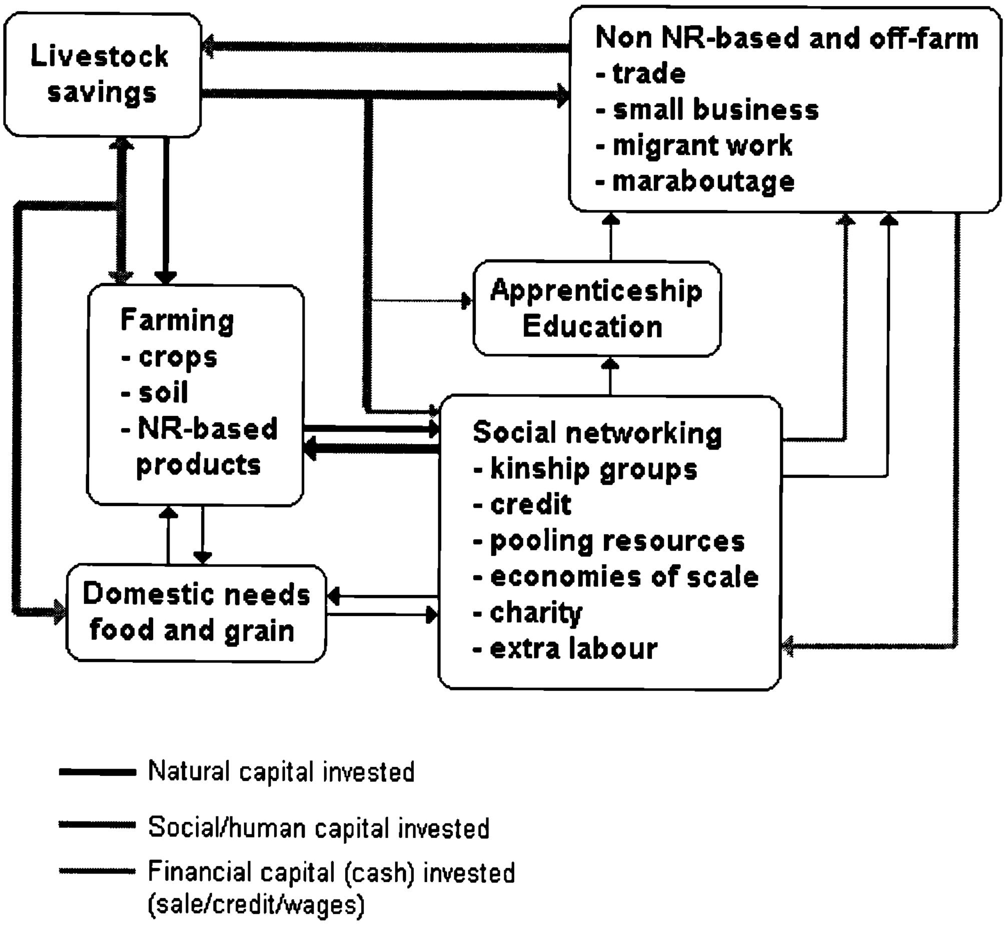
Second, the detailed case studies illustrated the importance of understanding the multiple and interrelated influences on household resource assets, which mean that farmers had to respond to a series of changing opportunities and constraints. The case studies highlighted the importance of sequential decision making and this provided an understanding of the differences in livelihood situations and the diversity of strategies. This adaptive performance is primarily based on reflection upon chains of related operations during the production process. Seen from this point of view the management of a farm can be regarded as a continuous series of experiments, by which, through the labour itself, the performance improves. A crucial element in this pattern is the ability to reframe the problem according to the changing situation and act according to the reframed picture, instead of following a 'thought-out design', which is more suited to agro-scientific hypothesis-testing. The case studies showed that farmers evidently see the process of changing their production as something that can be both isolated in time and space and also regarded as experience ('learning by doing'). Furthermore, the case studies illustrated how farmers adjust their management during the cropping period. Farmers did not consider these changes to be faults in their plan but part of spontaneous variation, which, in part, constitutes the essence of diversity.

Thus the changing and complex framework, within which decisions for land management practice operate, contributes to the difficulty in labelling households and the elusiveness of the concept of poverty. Within Fandou Béri, some characterisation of poor households can be seen from the analysis. The poorest households tended to be those of very small size, with insufficient labour to diversify effectively, or larger complex households with poor capital management. However, it is the large extended household that continues to constitute the most important institution for the mobilisation of labour and cash, the establishment and maintenance of social relations and some degree of protection against risk. For example, migration remittances are the most important type of contribution made to the household economy by diversification activities. For the household economies in the study, large families and the Fulani had the most diverse income. Fulani speculated in animals, cultivated land, received cash from members of the family away from the village herding stock and sold livestock products. The findings are broadly similar to research on people from the Bambara and Sénoufo cultures in Mali by Winter and Quan (2000).

Gubbels (1997) visualised an emerging pattern of household 'situation' over time, where an upward economic spiral develops for rich households and a downward spiral develops for poor ones. The case studies provide some evidence that this pattern exists in Fandou Béri. The models in figures 6.43 and 6.44 illustrate the patterns of capital investment, choice and dependency from the differentiated analysis.

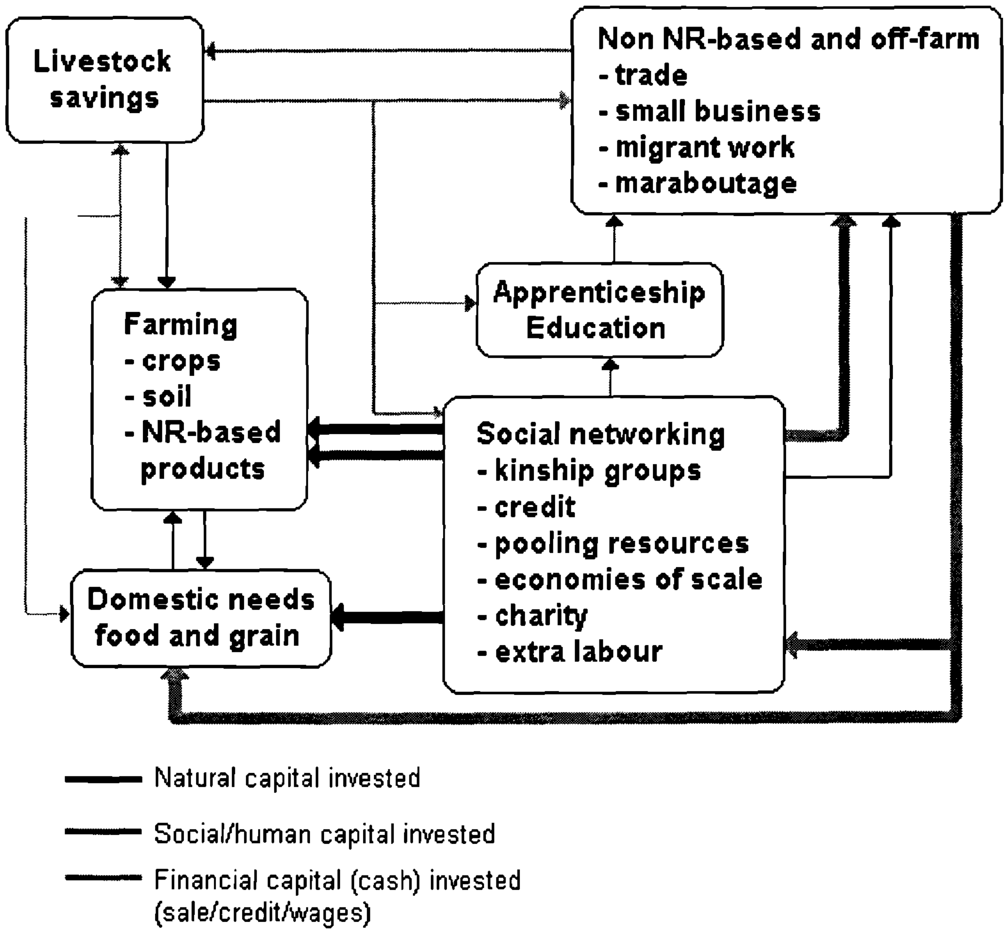
For large or wealthy households (figure 6.43), surplus cash was invested in smallstock, business or trade and dowries to marry additional wives to provide security, choice, nutrient inputs, increase the future family labour force and develop social networks. These households were able to access family labour quickly and to respond to production bottlenecks. They were also able to source their own manure inputs. Most important to these households was their choice to sell their livestock during times of difficulty or after harvest failure, preventing them from sliding down the economic spiral. Many richer households are therefore food-secure, because they have developed forms of co-operation, based on extended kinship groups, that enable them to spread risk, pool resources and achieve economies of scale. In addition, off-farm activities can be pursued if desired without making the household vulnerable to in livestock, small luxuries or to save for dowries. Flow line thickness is not shown to scale in figures 6.43 and 6.44, but an indicator of the importance of each capital.

Figure 6.43: Flows of investment, choice and dependency for large and wealthy Djerma households



In contrast, for small or poor households (see figure 6.44), misfortunes such as the loss of early crops, members' illness or any loss of labour during the farming season, could seriously diminish their capacity to invest. They are also especially vulnerable to drought, which can destroy the small livestock asset base that they depend on for security. Many invested in social networks to enhance their access to charity (e.g. for food, labour, manure, and credit). Social and human capital was strategic to the generation of cash. In small and poor households, the family members involved in non-NR activities were required to contribute all of their wages to the cost of tax duties, farm essentials or food supplies. To sustain off-farm work, the household would have to sell livestock or borrow cash. Instead, the preferred strategy was to sell NR-based products at local markets. This leaves households vulnerable to drought or shock in the local economy (lack of instant cash).

Figure 6.44: Flows of investment, choice and dependency for small and poor Djerma households



To some extent, redistributive mechanisms within Djerma society are likely to enable poorer households to benefit indirectly from the economic gains of more successful households (from their off-farm activity, extra labour, attractiveness to development projects offering new technologies and information, livestock and equipment investment, and gifts of food, manure, land or credit). However, Gubbels's own experience led him to conclude that the cumulative impact of new agricultural technology promoted by intervention projects is often insufficient to enable most poor households to enter the upward spiral towards increased food security (Gubbels, 1997). The question that arises is what can bring households into the upward spiral?

The analysis in this study highlights some possibilities: cash inputs generated by sons who migrate in the dry season (*exode*) and of credit to purchase grain, livestock (especially for transporting manure to the fields), extra labour and equipment or to invest in business. However, by no means did all the farmers have positive experiences with agricultural credit obtained through informal networks, and the issue of linkages between cash, credit and the impacting wider socio-economic system are discussed in the next chapter.

Agricultural extension projects in Fandou Béri have viewed improved access to technical information as the solution. Certainly there is evidence from other Sahelian extension (e.g. the SAFAR project – *Service d'Appui et de Formation pour l'Auto-Développement Rural* – see Gubbels, 1997) that providing farmers with greater access to information allowed ideas and experiences about new technology to have the same overall impact as did the promotion of on-farm trials. In Fandou Béri, extension projects committed themselves to both approaches. However, their failure to strengthen lines of communication within the village or provide poorer (and smaller) households with the means to the extra labour, cash, animal power or manure needed to make use of the new technologies, meant that they were unable to reach their defined aim of 'sustainable' agriculture. As this chapter has shown, locally-defined social structures, identity and consciousness are part the processes of decision and investment. The complexities and misunderstanding when attempting to manipulate social capital are discussed in Chapter Eight. The key problems preventing adoption was the lack of access to local sources of financial and human resources and weak forms of co-operation, which were far greater constraints to agricultural improvement than was a lack of technical knowledge. The one exception to this trend was the adoption of short-maturing grain cultivars by poor households because who can then sell their early harvests.

The evidence in this chapter makes a good case for a more detailed examination of the wider framework affecting household diversity. This wider framework incorporates linkages between the transforming structures and processes and rural dwellers' livelihood strategies. This is a necessary part of the process of contextualising the diversity in natural resource investment and management in Fandou Béri.

7
The wider framework of linkages in rural livelihoods

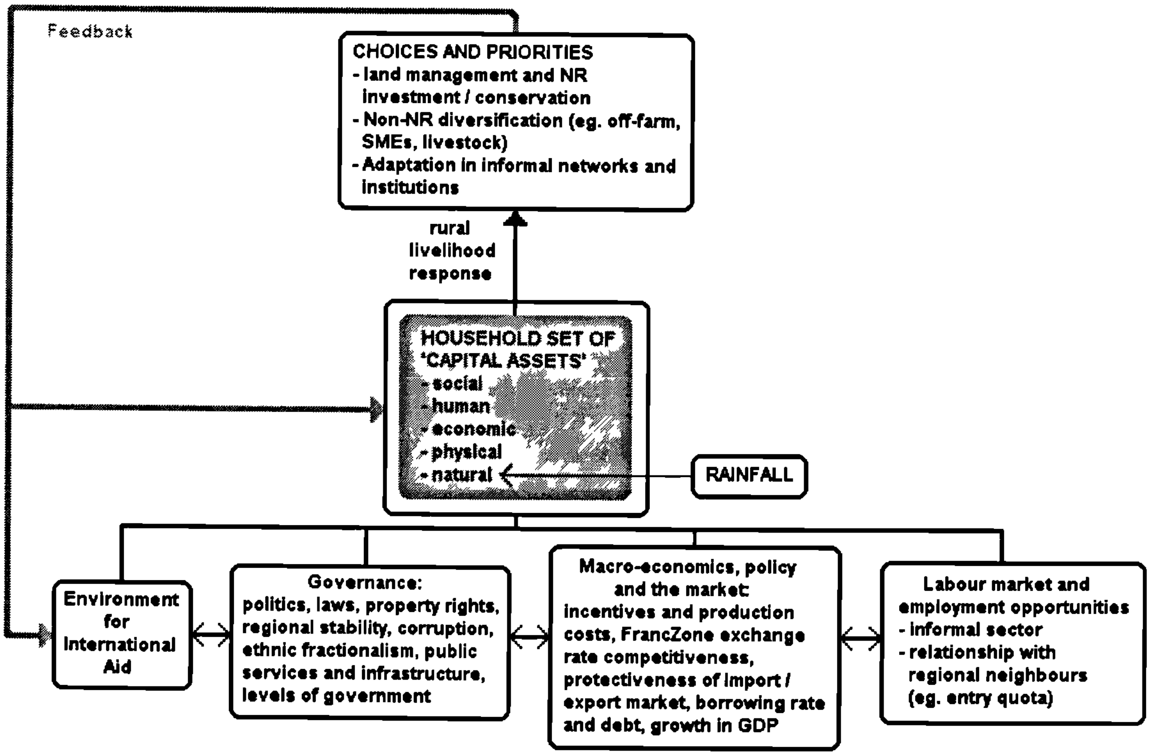
While Chapters Five and Six confirmed that Fandou Béri remains predominately a subsistence farming village, they also showed that the farmers produced crops and reared livestock for sale at local markets and were therefore subjected to the economy and the market. Moreover, it was found that the households in the study were not basing their livelihoods on farming or natural resources (NR) alone. Linked through networks, households in Fandou Béri were part of a wider community beyond their village, and non-NR strategies were influential in many livelihoods. It is difficult to view decisions relating to farm investments, such as in soil fertility, as separate from livelihood response as a whole.

A household's response to its situation was shown to be dependent on its set of 'capital assets' and these in turn were subjected to influences beyond the household's direct control (a detailed description of the set of 'capital assets' can be found in section 3.3). Inevitably, there are interfaces between rural dwellers' livelihoods and a wider framework of influences, which include the national economy, governance and policy, the informal sector, rainfall, and regional and international markets and macroeconomics. Figure 7.1 illustrates these linkages, which operate at different scales and different timeframes, but which impact parts of every rural household's activities and choices. The diversity in the responses of the households in this study, and the resulting pattern of farm management, can be partly attributed to changes in this wider framework (e.g. rainfall variability, new laws, incentives, work opportunities and structural restrictions).

Although rural dwellers are unable directly to control the wider framework, their activities indirectly influence certain factors (see the feedback mechanisms in figure

7.1). For example: their agricultural production and local cash-economy contributes to the national economy; their environmental management, information exchange and technological adaptation influences international research and intervention; their political support, traditional institutions and exchange systems and adaptation of new laws set the context for policy success and cultural ideology; their livelihood diversification into non-NR strategies and small or micro-enterprise (SMEs), labour investment and migration contribute to the development of the informal sector and regional employment.

Figure 7.1: Linkages between the wider framework, the household and rural dwellers' choices and priorities for resource management



The many interfaces in figure 7.1 are presented in a chronological summary (table 7.1) to show the cumulative impact of events on rural dwellers' livelihoods in Fandou Béri.

Table 7.1: Chronology of important events and their impact at the local-level

	Timeline of key events in Niger, the region and internationally	Impact on rural dwellers' livelihoods in Fandou Béri
1960s	- 1st Republic: end of French occupation in 1958 1960 elected President Diori and full independence - Prosperity/euphoria: good rainfall and harvests; discovery of uranium; infrastructural development - 'Nation-state' ideology (concentration of power, neo-patrimonialism) - Drought in 1965	- End of forced labour - Good harvests – able to stay in village, satisfaction in farming - Surfaced road, improved transport services to city and southern states (e.g. Nigeria) - State assistance in drought
1970s	- Droughts 1973-74 - 2nd Republic: 1974 Military Coup President Kountché - Political focus on self-sufficiency and agriculture - Growth of Niamey (funded by uranium boom) - 1979 international fuel crisis (damages Nigerien road haulage/exports in livestock, grain, groundnut and cotton)	- Harvest failures, food shortages, loss of livestock and short-term migration - Beginning of Fulani settlement - Option for long-term migrant work in mining and plantations (using kinship and business networks)
1980s	- Collapse of global uranium market - 1983-85 Drought and growth in intervention projects (on back of Green Revolution in Asia) - Unfavourable terms of trade for export/import, inefficient domestic capitalisation, dependence on French subsidies, economic crisis and stagnation, SAPs, growth in unemployment and corresponding growth in informal sector - 3rd Republic: 1989 President Saibou (after death of Kountché) with new promises of democracy	- Aid and research projects: cheap fertilisers, pesticides, GM grain, credit, conservation work, government extension agencies - Fall in price of cash crops at market – end of cotton and groundnut investment - Political disillusionment - Rise in seasonal migration
1990s	- Civil unrest, growth in independent political parties and NGOs - 1991 Interim government following Saibou removal - 1992-3 4th Republic Democratic elections for President Ousame and Multi-Party Assembly; end of civil unrest - Economic Liberalisation continues with SAP loans, 1994 CFA devaluation and inflation, cuts in public spending, liquidation of state assets, privatisation, restructuring, new laws (e.g. Rural Code) - Mid-1990s slump in agricultural commodity market and droughts, state unable to respond to food shortage - Political infighting causes state paralysis 1995 Multi-Party Assembly dissolved - 5th Republic: 1996 Military Coup by General Maïnassara; civil unrest; increased privatisation of aid to bypass state corruption - Economy growth (1997 GDP grows at 3.4%) and in 1998 Niger eligible for further SAFs (locked into restructuring – rising international awareness of poverty, globalisation and debt); process of decentralisation - Late-1990s rainfall improves but millet prices remain uncontrolled - Regional political change and instability (e.g. Nigeria); civil unrest in Niger, accusations of increased corruption	- High price for foodstuffs, goods and farm inputs – increasing importance of local cash-economy, rising taxation - End in subsidies on fertilisers chemical inputs unaffordable - End of invention project - Tenure insecurity - Cuts in services, healthcare, schools, government agencies - Higher taxation - Harvest failure, lack of grain for farm and food shortages - Delays in distribution of food and aid and rise in market cartels (high grain prices) - Challenge to traditional exchange systems and informal institutions from increasing restructuring, capitalisation, decentralisation and new rules - Growth in informal sector makes short seasonal work possible – urban-rural growth SMEs – diversification in labour investment - Increasing importance to income by youth and women - increased investment in livestock with cash economy

The timing of the events in table 7.1 provides an insight into their influence on agricultural choice, prioritisation and investment for households in Fandou Béri, as well as on livelihood diversification. For example, in the mid-1990s a series of low rainfall years caused harvest failures and food shortages, while at the same time vulnerable households were faced with the shock of devaluation, the collapse of agricultural commodity market, increased tenure insecurity, the loss in subsidised inorganic fertilisers and the increased price of essential domestic goods, grain and foodstuff at market. Together with already low 'capital' endowments, such events meant that farmers were unable to adapt crop management quickly enough (from cash crops, such as groundnut, to more locally suited crops or fodder crops). The farmers also needed to replace cash crop incomes and inorganic fertiliser with organic alternatives, chiefly from livestock integration.

Table 7.1 also shows that up until the mid-1990s, Fandou Béri had suffered declining public services and state support while incurring rising taxation. The cumulative result was a cash-poor local economy dependent on adapting to local exchange systems, new laws, social networks and ethnic relationships to cope with these wider influences. It is easy to see why many small or vulnerable households looked to invest within the growing informal sector (SMEs) or in short-term migrant work, despite the withdrawal of farm labour that this entailed. Savings were kept in livestock, which was a less risky investment that cash-cropping. The previous chapters showed that large socially-connected or wealthy households were able to respond most quickly to these changes because they had more choices, including access to high labour investments, livestock integration or sales and cash inputs.

This chapter focuses first on the effect of macroeconomics and land tenure laws upon rural livelihoods in Fandou Béri. Second, the non-farming component of rural livelihoods in Fandou Béri is examined in order to understand how the wider framework of household activities influences agricultural decisions.

7.1 The effect of currency devaluation and controlled public spending on livelihoods at Fandou Béri

In 1993, President Ousame's government committed Niger to economic liberalisation, privatisation, the restructuring and liquidation of state-owned enterprises, and better control of public spending in order to reduce national debt[1] (Olomola, 1991; Reed, 1996; Adedeji, 1999; Winters, 2000). These macro-economic policies had direct implications for smallholders' livelihoods in Fandou Béri.

7.1.1 Impacts on public services

Cuts in public services reduced the quality of healthcare and schooling. The school in Fandou Béri closed in 1997 because the government stopped paying the teacher. The teacher left to work in Ivory Coast and the local administration claimed that the village was responsible for the cost of hiring another. The school remained closed during the study period (1998). Niger has one of the lowest literacy rates in the world, with only 29% of primary school age children receiving education (FAO, 2000).

7.1.2 Impacts on the agricultural sector

Public expenditure adjustment reduced access to productive resources for farmers in Fandou Béri (see box 5.8). Chapter Five showed that farmers were dependent on rudimentary technology such as hoes and cutlasses for carrying out major farming operations, creating demands of household labour and capital. Not all farmers had access to credit facilities with which they might secure better technology. Even for the small group of farmers in the region who did use chemical fertilisers, access was difficult because the distribution network was beset with myriads of impediments leading to late arrivals, misapplication and wastage (Tshibaka, 1998; Breman *et al.*, 2001). Cuts in government subsidies to the agricultural sector made most farm inputs unaffordable to farmers, such as the chemical fertiliser that had been promoted by intervention projects in Fandou Béri (see Chapter Four). Input credit dried up and government-provisioned rural assistance, advice and infrastructure crumbled. As crop

[1] Despite GDP growing at 3.4% in 1997, the same as inflation, national external debt for Niger increased to 800 billion f CFA ($1.6bn) in 1998 (FAO, 2000).

yields fell, farmers were not able quickly to respond to the rapid changes because they were constrained by a lack of cash. Investment in alternative organic inputs required livestock integration and labour investment, which were processes that could not respond quickly. The whole management system needed to be changed.

Farmers' management difficulties were compounded by a slump in the international agricultural commodity markets and an undermining of the price of their cash crops at local markets. A number of factors had contributed to this problem. First, government policies before Structural Adjustment had contributed to destabilising the structure of price incentives that might have benefited agriculture and consequently the growth of agricultural output[2]. Second, the dismantling of the Bretton Woods international financial regulatory system had an impact on market prices (Adams, 1990; Tshibaka, 1998; Adedeji, 1999). Third, after 46 years and several serious recessions, 1994 was the year the Franc Zone attempted to make up the income losses of earlier years with currency devaluation (African Development Bank, 1994). Devaluation of the franc CFA caused sudden inflation (Diagana *et al.*, 1999). Villagers had to pay high cash prices for foodstuffs, goods and grain. Fourth, economic liberalisation created an unfair international trading system (Mkandawire and Olukoshi, 1998). Finally, the market in millet, the main staple, remained unregulated, which made prices vulnerable to cartels, disruption in transportation and drought (Mkandawire and Olukoshi, 1998).

7.1.3 Impacts on agricultural investment

SAPs were based on a prediction that the cuts in government support to the agricultural sector would be met by the private sector, despite the lack of incentives (Spoor, 1997; Ng'ong'ola, 1999; Lopez and Hathrie, 2000). However, placing the development of agricultural objectives in the control of the private sector produced further stagnation and forced farmers to adapt and find their own solutions. The private sector has not been able to remedy the lack of investment, due largely to the associated risks, as well as the limited capacity and unwillingness of private sources to invest in agriculture (Ng'ong'ola, 1999).

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[2] The Debt Service Burden for Niger, as a percentage of export receipts, rose from 33.0 in 1989 to 42.0 in 1990 (ECOWAS, 1991).

7.1.4 Downsizing of intervention projects

The changes in the wider economic environment in the mid-1990s coincided with the end of intervention projects and of the visits of extension workers to the village, and the opportunities that they had brought. Given the labour and cash constraints experienced by the study households, most abandoned the practices promoted by the projects (see section 5.1 and the cases studies in Chapter Six). The lack of permanent adoption by farmers suggests that simply providing better information and technology did not promote investment or increase access and entitlements to resources (see also McDonald and Brown, 2000).

7.1.5 Food security and the state

Food security for households in Fandou Béri did not improve with the new Military regime of General Maïnassara in 1996. Poor rainfall continued to give low yields and grasshopper infestations devastated some farmers' crops (see box 5.24). Households could not afford pesticides and struggled to buy additional seed. There were food shortages in the village in 1996 and 1997 and households began to sell assets (see case studies in section 6.3). The impoverished finances of the state made it less able to respond to rural food shortages and this caused delays in grain distribution. There was a rise in speculation by dishonest merchants and grain prices (these are uncontrolled) and increasing dependency on international aid (Dijkstra *et al.*, 1999).

Despite the difficult situation for many households at the end of the 1997 season and the high price of grain in early 1998, it was not until July 16th that the Nigerien authorities announced the national sale of 8,000 tons of maize (for food) to prevent grain prices rising any further. Cereal prices in Fandou Béri did not stabilise until September, and at very high levels. Most millet on the market had been imported from Mali. However, Niger normally needs to import cereals and under better rainfall regimes prices usually begin falling sometime in September with the approach of the harvest. The early harvest in 1998 brought prices down earlier than expected. After three consecutive years of below-average harvests, this resulted in subsistence rather than famine for many rural Nigeriens. The government responded to the high cereal prices, but only because of the assistance from international aid organisations. By the end of July, international sources had provided 7,636 tons of cereal food aid for subsidised sale nationally (USAID, 1998).

Despite these efforts, the people of Fandou Béri received no cheap grain in the village market and had to buy expensive grain from larger markets. Lack of assistance may have been due to the proximity to Niamey. However, the government addressed neither the issue of market control nor the effect of imported grain on locally grown cultivars and local biodiversity. The amount of aid was also lower than earlier in the decade. The World Bank reported that official aid fell to $19 a head in 1998 from $32 a head in 1990 (Elliott, 2001), as OECD countries cut aid budgets. This was at a time when sub-Saharan growth fell sharply in the aftermath of the global financial crisis of 1997-98 with per capita incomes falling by 1% in 1998. Moreover, the government response was very late. The fact that farmers were able to harvest enough to meet household subsistence needs was more a result of household asset sale and sufficient rainfall (that was sustained into October) than the result of the distribution of international aid. If 1998 had been another drought year, many in Fandou Béri would have faced extreme vulnerability and would have needed to sell further household assets. The World Food Program (Programme Alimentaire Mondial) has committed itself to $22.2 million, or 48,000 tons of food aid to Niger, to be given between 1998 and 2002. Farmers in Fandou Béri welcomed this aid but remained sceptical about the ability of the state to deliver at 'critical moments'.

Food security should be placed in a national context. The dynamic situation for villagers in Fandou Béri is linked to patterns of national production, availability, infrastructure and pricing. While production remains tied to rainfall (see figure 4.1), the national pattern shows growth in crop production, and especially in cereals (figures 7.2, 7.3 and 7.4), over the last twenty years. This is despite population growth, low inputs, low technology and reduced public support.

Figure 7.2: Total groundnut production in Niger 1980-1998 (Source: FAOSTAT, 2001)

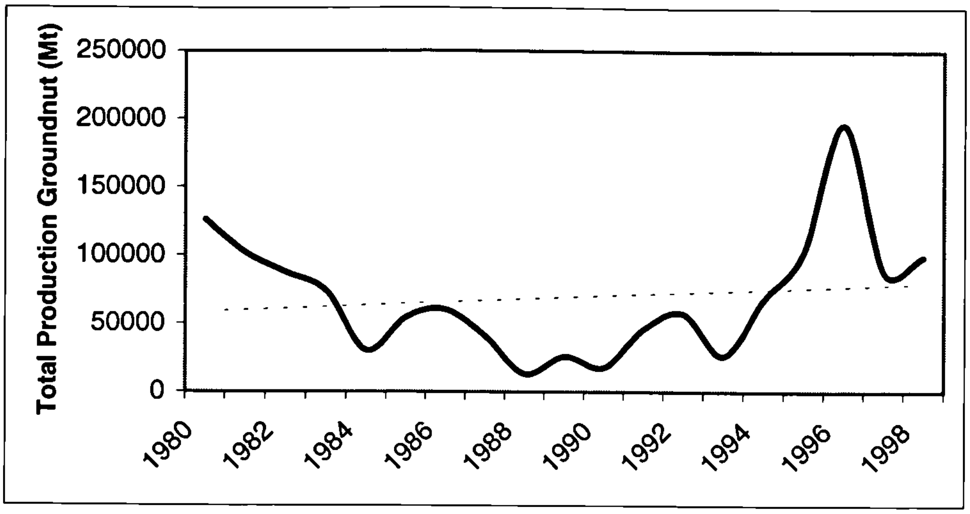


Figure 7.3: Total cowpea production in Niger 1980-1998 (Source: FAOSTAT, 2001)

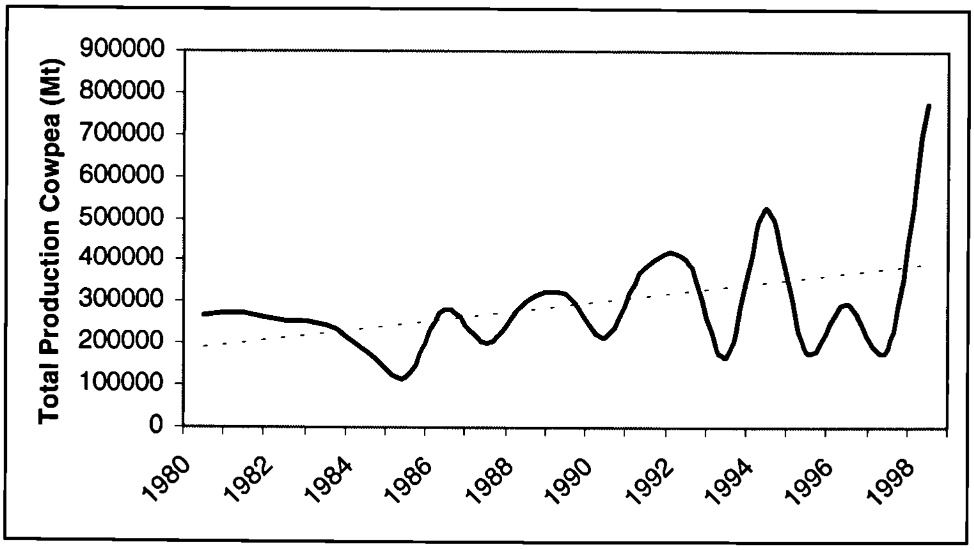
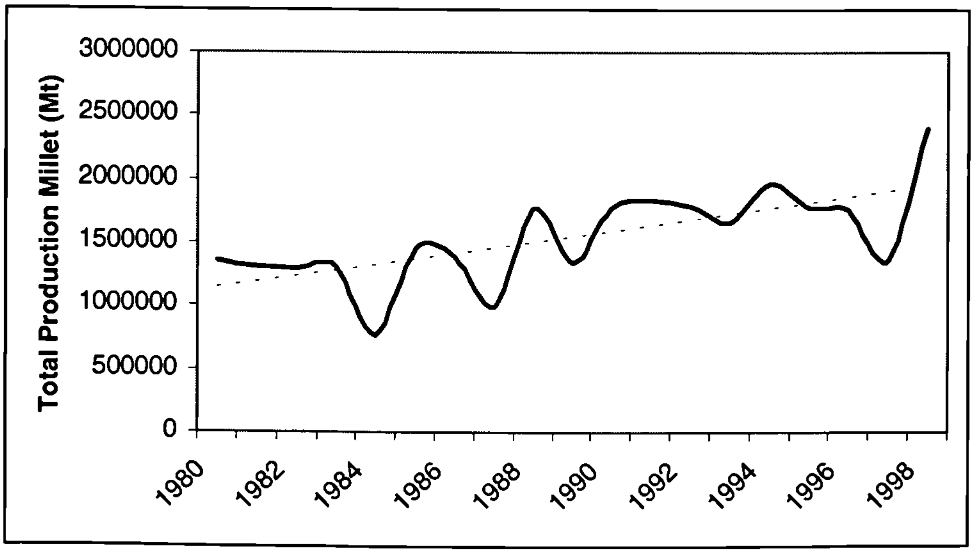
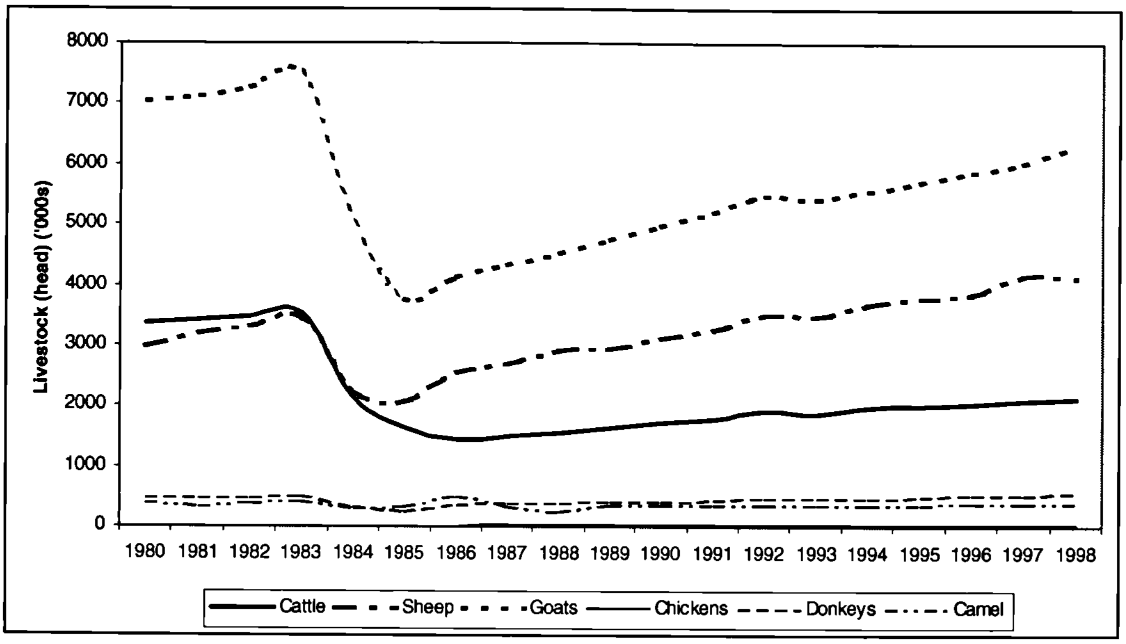


Figure 7.4: Total millet production in Niger 1980-1998 (Source: FAOSTAT, 2001)



A similar trend can be seen in livestock production (figure 7.5), following recovery from the droughts in the early-1980s[3]. This suggests that farmers are using their available knowledge and resources with great skill and using more organic inputs.

Figure 7.5: Livestock production in Niger 1980-1998 (Source: FAOSTAT, 2001)



7.2 The effect of the Rural Code on tenure security, informal institutions and the social meanings of space in Fandou Béri

The government's preoccupation with privatisation, and the positive evidence from neighbouring countries, led to the introduction of tenure laws in the mid-1990s (1993 Principes d'Orientation du Code Rural and 1995 Draft) (Lund, 1993; 2000). Privatisation of land is tied to the promotion of sedentarisation and of mixed farming, which are seen to be necessary under increased population pressure (Binswanger and McIntire, 1987; Gass and Sumberg, 1993; Ramisch, 1996). Based on the premise that customary land tenure systems are insecure and encourage conflict, the aim of the new laws for registration was to create tenure security and encourage rural people to invest in their land (Bruce, 1993). It was assumed that formal ownership recognised

[3] Note the rapid recovery in the number of small ruminants, but less rapid recovery of cattle stocks. Turner (1999d) commented that this pattern may be the result of decreasing Fulani labour investment in herding, increased sedentarisation, decreased economic security, more restricted grazing arrangements due to increased crop area and increased activity by Djerma in smallstock holdings.

by the State would be enough of an incentive. However, locally recognised forms of ownership already existed, and investment, as shown in this study, is dependent on the social and economic conditions within the household and the wider environment rather than tenure security alone. As both Barrows and Roth (1990) and Maxwell and Wiebe (1999) have argued, land registration would therefore be best viewed as a policy to assist in the evolution of land tenure institutions already under way instead of a policy to stimulate a fundamental change in farmers' economic behaviour.

7.2.1 The customary land tenure system at Fandou Béri

There is a well-defined customary system of access to land at Fandou Béri. Cultivation rights are established by clearing a new piece of land. The village chief is responsible for giving the right to newcomers to cultivate on the village territory even if individual Djerma have already granted them access to their land. No reported cases of land sales were recorded during the study, and it would seem that land remains outside of market transactions using cash. Since land is not 'sold', the two informal institutional processes that have developed to cope with the increasing demands on land are (a) the subdivision of land (Islamic inheritance system) and (b) the credit-exchange system.

(a) Subdivision has guaranteed young men in the family lineage some of their father's land upon his death (i.e. the Islamic inheritance system), although this system has not promoted efficient farming practice. As box 5.7 showed, farms are highly fragmented. The new tenure laws aim to change this practice, making fragmentation less common, and farms more efficient. However, farm fragmentation is also a response to managing risk in a variable environment.

(b) Land can be borrowed through the credit-exchange system (i.e. accessing land through networks). Examples of this process (as credit and pledge) were described in detail in the case studies in section 6.3. It allows individuals who have a surplus of cash to borrow a plot of land, or often a whole field, from another family with available land or in need of credit. The process is also conducted as a pledge, although respect must be shown when borrowing land (e.g. giving landowners gifts of appropriate size, taking sides in social disputes). A percentage of the harvest is usually pledged to the owner in return for the use of the land. The general practice is to borrow the land until it needs to be fallowed when it is usually returned and another piece of land is borrowed.

7.2.2 The relationship between the evolution of customary tenure systems and socially defined meanings of space

The customary tenure system in Fandou Béri has evolved with social change, and therefore the field pattern reflects village history, land rights and traditional family lineage. This makes the customary tenure processes inseparable from power and status (the relationship between power, identity and land which gives historical meaning and value to physical space) (see section 6.2.4). Customary tenure systems have traditionally been used by Djerma to control space, immigrants and other villagers, because local perceptions explicitly made a link between land, identity, history and spirituality (see boxes 5.25 and 5.26) in a way that registration laws do not. For example, farmers from early lineages control the land around the watering holes, which gives them status in the village.

However, traditional meanings of space have adapted with social change, forcing customary tenure systems to evolve. This evolution has permitted newcomers (such as the Fulani) to settle in the village, as well as enterprising Djerma farmers without small farms to access extra land (see section 6.3). Exposure to symbols of wealth besides land (cattle, for example), interaction with formal and development institutions, and the diversification of livelihood activities, all challenge traditional meanings of social space. As 'traditional' values become more diverse, the control associated with place becomes less critical, and the evidence from Fandou Béri suggest customary tenure systems become more flexible (Chapter Five and Six).

7.2.3 The challenge of combining registration law and customary systems to create tenure security and encourage soil investment

There have been many criticisms of the new registration laws (e.g. Gado, 1996; Lund, 1998; 2000). Bruce *et al.* (1994) suggested that the introduction of property rights was inappropriate, as they underestimated the mechanisms in customary tenure that enhanced food security and overestimated the efficiency effects of private property in economic environments that were characterised by multiple market imperfections. Furthermore, the Rural Code's stated aim of recognising customary definitions of tenure rights leaves room for ambiguity and abuse, while the promotion of registration and titling is expensive, time-consuming and requires donor support. As Gastaldi (1995) and the Winter and Quan (1999) have pointed out, the land titling reforms have ignored the concept of user-rights and optimal distribution. In the customary system, tenure security is as much a result of user-rights as of ownership. For example, when women and young men cultivate on borrowed land with short-term contracts, it might appear that their tenure is insecure, but they usually farm kinship fields and therefore repossession is part of overall household management plan on year-to-year strategy. Farmers often perceive customary land rights as secure because there is strict regulation by the local customary authorities and penalties for those who are disrespectful.

However, even if a farmer has established user-rights, the evidence from Fandou Béri suggests that ownership is a consideration for farmers when deciding where to invest precious resources. They invest in their own land first and then in the borrowed land (see boxes 5.1 and 5.21 and case studies 6.3). Gavain and Fafchamps (1994) found similar results elsewhere in Niger. In addition, while the study by Hopkins *et al.* (1995) also in Niger produced similar findings to this study, it also found that farmers invested in their food security fields before their cash crop fields. These are not the same processes as occur in privatisation, which is altogether a more complex issue. This implies that titling is unlikely to change investment patterns, since sources of inputs and labour will remain limited (see section 6.2.3).

The case study evidence in Chapter Five and section 6.3 indicate that farmers are flexible and adapt to changes in land situations, in rainfall and in their own resources (e.g. cultivating more borrowed land when there is more family labour). Private tenure will not improve on the flexibility of the customary tenure system and it is unlikely that newcomers would be able to buy land anyway. If fallowing is becoming less important to farmers and they increase their interest in manure application to raise nutrient levels, then the customary tenure system may not have such a strong hold, because according to the case study evidence, the primary reason to borrow land is to rest your own land (see Chapter Five and Six). However, it is unlikely that the tenure laws in Niger will end the customary tenure system, especially as it relates to households of the same kinship group. Nor will it solve the problem of subdivision. Cash-sales of land might promote polarisation in household vulnerability if secure opportunities outside of farming remain scarce. Moreover, they would provide no guarantee of increased manuring (see Gavian, 1993). Platteau (1992) proposed that when compared to systems with cultural norms and customary laws, private property rights are the form of property rights with the highest transaction costs, which would create highly differential land use allocation investment.

7.2.4 The Rural Code and tenure disputes

Platteau (1996) was concerned that the rural code brought new possibilities for conflict at a time when livelihoods were still recovering from drought and economic change. In Fandou Béri, the mere announcement of a titling programme unleashed old and new disputes (see sections 4.3, 5.5 and 6.3 also Batterbury *et al.*, 1999). These disputes are partly because of the perceived increase in risk of farming in a less flexible system, and partly because property is still considered a social convention providing rights for several actors with kinship ties, despite the individualisation of family land. Confusion remains over the Rural Code's rule of 'three years and land rights' and a fear by farmers that lending land will lead to conflict[4]. This confusion and fear has exacerbated tenure insecurity in Fandou Béri, weakening the system of trust. Consequently, it is now more difficult for new people to settle in the village or for passing herders to find grazing land during the agricultural season.

Two types of dispute exist at Fandou Béri: disputes between Djerma (between Djerma within the village and between Djerma in villages usually through extended kinship networks); and disputes between Fulani and Djerma. The way these land disputes are dealt with was transformed by the Rural Code (Lund, 1998). It gave legal sanction to customary-dispute mechanisms, the establishment and legitimisation of customary-based resource management institutions (co-operatives and Comités de Gestion de Terroirs), and created rural land commissions (Commisssions foncières) to resolve tenure disputes. These processes may have undermined local systems of conflict

[4] 87% of farmers interviewed in the study believed that the new tenure laws had discouraged them from lending land because the process would be abused, even by neighbours.

resolution (Lund, 2000). One exception exists, where there has been a renewed emphasis on lineage in resolving land disputes, which runs contra to the new meanings being attached to social space by newcomers, entrepreneurs and young farmers (section 7.2.2). The Rural Code has reinforced the traditional power structure. It has stopped the flexibility afforded by rotation, essential to farmers with low inputs, thus ignoring the way in which rights to resources shape opportunities to meet short-term consumption needs. This analysis has suggested that access to land and natural resource assets are not exogenously controllable, and that 'tenure' is not a static concept to farmers.

7.2.5 The impact of decentralisation on the tenure system

The impact of the decentralisation process in Niger, following the 1998 Administrative Reform) on the tenure system or resolution of tenure disputes in Fandou Béri is uncertain. There are usually only two outcomes of decentralisation: either a 'deconcentration' of power from the centre, to lower level structures which retain features of the system, or a genuine process of profound change and power-sharing, which increases the level of control by local people over their own livelihoods (Coulibaly, 1994; Winter, 1998). While it is true that land allocation and natural resource management have not been the focus of the regional council, their activities have impacted local households and therefore indirectly affected the allocation of rights, the distribution of power and how land is managed.

7.3 Livelihood diversification and the household economy

Farming has always been only one part of Sahelian household livelihoods (also see Ellis, 1998; 2000; Hampshire and Randell, 1999) and villagers in Fandou Béri are no exception (Table 7.2). The livelihood system has always been maintained by feedback linking various activities, including farming, to the household economy (as shown in figure 7.1). For Fandou Béri, the weak local cash-economy meant that farm output has seldom yielded a profit for most families and a large proportion of household cash has to be found from the breeding and sale of livestock and non-farm activities (some not based on natural resources).

Those individuals who entered the informal sector as long-distance migrant workers were not so much 'self-employed', as employed in small businesses managed by others, through a network of contacts. Villagers from Fandou Béri had established contacts in Nigeria and the Ivory Coast from the 1970s onwards. They generally preferred networked employment because it gave them more flexibility than would 'self-employment' because activities are seasonally dictated and the risk was lower. The young used the informal sector to gain valuable work experience in micro-enterprises (technical or business skills), which was useful when they returned home, or if they needed to find employment again. The vacuum in agricultural credit facilities and public extension facilities left by the government and unfilled by the private sector contributed to the 'push forces' for households in Fandou Béri. The households sought to reduce their vulnerability by diversifying income outside of agriculture and maintaining networks through migrant work. This is not to say that families in Fandou Béri were not self-employed in local strategies or in short-distance movements. Micro-businesses featured in the portfolios of several households (table 7.2). Family enterprises, home-based work and street vending created most of the off-farm income in Fandou Béri.

Table 7.2: Experiences of the informal sector (1997-1998)

	% of households from study involved	**Timing of activity**	**Ethnic group practising service or trade**	**Members involved**	**Place of activity**	**Use for Cash**
SERVICES						
Transport arrangement	10	All year	Djerma	Men	From Fandou Béri	Personal, farm
Religious duties	20	All year	Djerma	Religious leaders	Fandou Béri and other local villages, Niamey, maraboutage in other districts / countries	Household domestic and foodstuff, festivals, community benefit
Collection of manure for gifts, cash, exchange	65	Mostly Jan - May	Djerma	Mostly children / also some men and women	Farms within Fandou Béri	Household domestic, Farm
Traction hire (bulls)	10	All year	Djerma	Men	Within Fandou Béri	Farm
Plough hire	5	Feb - May	Djerma (and to	Men	Within Fandou Béri	Farm

			Fulani)			
Cart hire	40	All year	Djerma - Fulani	Men	Within Fandou Béri	Farm
Hairdressing	45	All year	Djerma	Women	From home	Personal
Tool/ Equipment mended	5	All year	Djerma	Men	From workshop /home Fandou Béri	Business, household foodstuff
Milling	5	All year	Djerma	Men	From workshop Fandou Béri	Business, Household foodstuff
Agricultural advice	5	All year	Djerma	Men	Fandou Béri	Farm
Shop	5	All year	Djerma	Men	Fandou Béri	Business, household foodstuff and domestic
Traditional medical advice for animals or people	10	All year	Fulani Djerma	Men/ women	From home Fandou Béri	Personal
Livestock rearing for others	20	All year	Mostly Fulani (Some Djerma)	Men / women	From home at Fandou Béri (Djerma), Animals kept with Fulani herd / some moved with Fulani herd to Nigeria and within Niger	Further livestock investment / veterinary costs and animal feed / farm (Fulani), household domestic (Djerma)
Cash manure contracts	15	End of harvest Sep – Nov (field) / Feb (fallow)	Fulani to Djerma	Men	On Djerma farms in Fandou Béri	Further livestock investment or veterinary costs
Credit loans	20	Nov (for migration or trade) / Jan- Aug (for grain, festivals, foodstuff)	Djerma	Men	From home (Fandou Béri)	Repayment (household or farm) or gifts (foodstuff)
Domestic work (water carrying, washing, grinding millet)	40	All year	Djerma Fulani	Women and children	From home and at Fandou Béri	Household domestic and foodstuff, personal
Chieftenship (commissions from tax collection, administration, conflict resolution)	Chief	All year	Djerma	Chief	From home, village meetings	Household foodstuff and domestic, personal, credit
Casual labour (cultivation) (Note: this does not	85	Feb - Aug (village) / Dec - May (southern	Djerma	Men and older boys	Farms in Fandou Béri, Also migrant work on farms	Household foodstuff and domestic, personal (credit

include the informal institution of labour exchange)		countries) Especially since the mid-1990s			in Niger, Ivory Coast and Benin	for Koranic school), farm (paid labour)
Labour (mining)	20	Dry season and for longer 'Bachelor wage'	Djerma	Men and older boys	Ghana, Nigeria	Personal (often bridewealth) / household domestic and foodstuff, livestock investment
TRADE						
Cash crops (some millet, groundnuts, beans, hibiscus, some cassava and dry season vegetables)	55	Mostly Oct - April	Djerma Fulani	Men / Women	Markets at Fandou Béri, Wankana, Hamdallaye, Niamey and other local markets	Household domestic, farm, livestock investment, transport costs, personal, loan repayment, credit
Foodstuffs (groundnut oil, groundnut biscuits, flour cakes, 'boule', 'samboula', millet pate, 'gari', spices and collected plants for sauces)	80	All year	Djerma Fulani	Women and children	From home, Fandou Béri market	Household domestic and foodstuff, personal
Animal products (milk, butter, soured millet)	15	All year	Fulani (can be exchanged for cereals)	Women	From home, Fandou Béri market	Household domestic and foodstuff, personal
Animal fodder (hay, fresh grasses and leaves)	35	All year	Djerma Fulani	Men / Women	Local markets including Fandou Béri	Household domestic and foodstuff, farm
Wood fuel	20	All year	Djerma	Men / Women	From home, markets at Fandou Béri, Hamdallaye, Niamey	Household domestic, farm (cereals), personal
Livestock breeding and sale	95	All year	Fulani Djerma	Men / Women	From home, markets at Fandou Béri, Hamdallaye, Ballayara (herds also in Niger, Nigeria and Mali)	Further livestock investment, household domestic and foodstuff, festivals
Petty trade (cigarettes, Kola nuts, batteries)	45	All year or dry season	Djerma	Men / older boys / some women	From home, markets at Fandou Béri, Wankama, Dantchiando	Personal, savings
Business	50	Between	Djerma	Men and	Niamey,	Personal

selling cloth, clothes, shoes, blankets, watches, black market goods		Nov- May (esp. since mid-1990s) or longer ('bachelor wage')		older boys	Nigeria, Ivory Coast	(including for apprenticeship), investment in livestock, farm, household
Electrician	5	Periods through the year	Djerma	Man	Niamey	Household domestic, farm
Jewellery	10	All year	Fulani	Women	From home or local markets	Personal
Calabash	5	All year	Djerma	Men	Local markets	Household domestic
Clay bricks	5	Dry season	Djerma	Men	Fandou Béri and local markets	Household foodstuff and farm investment
Beds	10	Dry season	Fulani	Women	Fandou Béri market	Household domestic
Grass Products (Mats, Brushes and building products)	30	Most dry season	Djerma Fulani	Men / women	Markets at Fandou Béri, Kollo	Household domestic and foodstuff

(Source of data: SERIDA database and own fieldwork)

The main issues arising from the data in table 7.2 are discussed in the following sections. These include the contribution to household livelihoods from women's activities, the co-operation between Djerma and Fulani, the mixing of cash-based and non-cash transactions from NR products and non-NR activities.

7.3.1 The role of women in household adaptation

While farming is a male dominated activity, women's activities are an important part of the household livelihood, within which adaptation decisions for natural resources are taken (tables 7.2 and 7.3 and case studies in section 6.3). The cash crisis observed in many households in Fandou Béri means that the financial and social contribution from women's activities is especially significant, although their contribution is only just beginning to be formally measured (Charmes, 1996). Van Haaften and Van de Vijver (1999) found evidence that women in the Sahel are under increasing stress to provide support in household coping strategies.

Activities were preferentially conducted from the home, but many unmarried and older women sold products at market. Girls touted home-made food or collected natural resources, such as plants or woodfuel. All the women in the sample found income to cover some their households' basic cash needs. Many succeeded when their husbands failed. They were able to spend the cash they earned on household necessities (often sold at inflated prices) and luxuries while their men went empty-handed. Some women even lent money to their husbands to cover farm expenditure. Women's cash budgets were generally positive compared to men's cash budgets (see table 7.3 and discussion in section 7.3.3), and their contribution more significant during poor-rain years when harvest were low. Unmarried women or older women carried out some gardening on loaned plots in fallow fields, usually kinship land. Women that were more affluent invested in non-farm activities, in particular smallstock, and hired domestic labour. Livestock sales undertaken by men on their behalf made a substantial contribution to household incomes (e.g. a 100% mark-up price could be made on sheep before festivals).

While it is convenient to refer to the household as the basic productive and consumption unit, this can be misleading, because, as the case studies in section 6.3 have shown, some households functioned only as partially linked sets of sub-units differentiated by gender or age. The extended family, including women, in the household could play an important role in expanding the household's capacity to respond to change quickly. For example, several wives were part of the family labour supply, provided access to extended family labour and land, financial and equipment loans, gifts of grain and manure, and brought in income (from market sales). All this provided greater choice and lower risk. Women also played an important role in maintaining relations with natal families by investing their own household resources (usually gifts and domestic work), thus ensuring that these networks could be used in times of agricultural difficulty (e.g. extra labour, gifts of manure or seed). Non-cash contributions are discussed in section 7.3.3.

7.3.2 Ethnic interaction and co-operation

Table 7.2 shows that ethnic interaction and co-operation is widespread in the village. Through this co-operation, the specialised roles and skills of the Djerma and Fulani have been emphasised, helping to maintain to trust and identity and explain the generally positive inter-ethnic relations in the village. Many ethnic exchanges were based on a non-cash system (with compensation in kind or a gift of appreciation).

This means that categorising ownership of technology and equipment (e.g. ploughs, carts or donkeys) does not present the whole picture of use. For example, the case study information in Chapters Five and Six showed how many households lent or borrowed donkeys and carts for manure transportation to fields. In a cash-poor economy, borrowing and specialised exchange offers a much less risky strategy than cash exchange. It also explains why many households chose to invest resources in social networks (kinship gifts, labour exchange etc), as highlighted in figures 6.43 and 6.44 (Chapter Six), rather that directly into the farm. In this way, they are improving future access to resources and ensuring entitlements. It is important to understand these interactions to understand household patterns of farm investment and land allocation.

7.3.3 Cash-based and traditional exchange systems

Fandou Béri has become more integrated into the market economy and transactions have become increasingly commercialised (e.g. in the case of manure exchanges), and there is no reason to believe that the non-cash economy will not continue to play a role in the process of farm investment. The local cash economy is embedded in the local histories and cultures, but it also interacts within the wider framework, and is continuously transformed. To ignore the informal institutions or 'social capital' within which the cash-economy operates would certainly result in an underestimation of local investment and productivity. It is also important to know that investigating cash-based transactions separately would not give a good indication of total investment, because not all 'capitals' are monetised (i.e. 'capitals' are both commodities and non-commodities) (see case studies in section 6.3). Cash-based budgets for Fandou Béri show that many households have deficits, especially in the male side (table 7.3). The table shows that while all the sample Djerma balances are negative, Djerma have higher cash expenditure than Fulani. It also shows that Fulani have stronger household cash flows than Djerma, especially in the women's budget. The flows of cash need to be placed in context of the wider household capital budget, with flows or substitutions of capitals from and into the farming component of the household livelihood (see figures 6.43 and 6.44, and table 3.1).

Table 7.3: The cash-economy: household budgets divided by gender and ethnic group

		Budget (f CFA)*		
		Cash receipts	**Cash expenditure**	**Balance**
All households (N=16)		253,616 (1.08E+10**)	329,473 (4.34E+10)	-75,857
Djerma (n=13)	**Household**	247,075 (1.10E+10)	342,489 (5.03E+10)	-95,414
	Men	142,715 (7.30E+09)	301,552 (5.40E+10)	-158,837
	Women	97,800 (2.44E+04)	33,937 (5.10E+08)	+63,863
Fulani (n=3)	**Household**	281,958 (8.88E+09)	273,066 (9.72E+09)	+8,892
	Men	198,092 (2.22E+09)	257,7717 (7.70E+09)	-59,625
	Women	83,867 (2.22E+09)	16,167 (1.59E+08)	+67,700

**SERIDA data for sample households in study   **variance in variable*

There are many factors (e.g. government structures, policies, laws, markets, cultural practices and institutions) that influences how rights and responsibilities are defined and also the terms on which different capitals can be used, regenerated or substituted for others. They are decisive in determining whether poor or vulnerable people can use their capitals. Chapter Six concluded that poor, small households use more social than financial capital substitution (e.g. kinship support for grain consumption and farm inputs) while more wealthy households (see figures 6.43 and 6.44) make more cash transactions, which reinforces socio-economic differentiation. The following three case examples[5] illustrate this socio-economic differentiation, the evidence of non-cash receipts (e.g. gifts, ceremonies and social obligations) and the importance of livestock as a sink for cash (i.e. savings and speculation).

(a) Case One[6]

The household cash balance appears in deficit for this large Djerma household but this disguises its ability to make substantial non-cash substitutions of 'capitals' from and into the farming component. The primary source of cash was crop sales (sold by both the male head of the household and his first wife), livestock sales (cattle sold by the male head and goats and sheep by his wives), off-farm work in the Ivory Coast (male head sold cloth in friend's 'business'), sons' off-farm work, and the second wife's petty trade. However, hidden non-cash income came from

[5] These case examples review the household seasonal situation at the end of the 1997 season.
[6] Family names of households are reserved for reasons of privacy.

their subsistence crop, gifts of grain from land tenants (used in planting), gifts and food from networks while on migration, ceremonial gifts from kinship networks, and farm labour from other farmers. The cash budget (included loans and payment to Fulani for a manure contract, travel and purchase of cloth, taxes, consumables and household essentials (including extra maize and wood), livestock speculation, payment to labourers, payment for wife to visit family in another town and markets[7], vitamins and veterinary bills, farm pesticides). However, this too had hidden transactions (loans to family members, gifts to a merchant, the village chiefs and family, grain to landowners for additional borrowed fields, gifts to family for use of cart). The most important aspect of the apparent deficit in the cash-based budget was that much of the household savings were tied in livestock (a non-cash sink for savings and a source of future profit). Understanding the full 'capital' balance shows that this household was capable of investment and, at the time of the study, even wealthy.

(a) Case Two

This small Djerma household has cash-receipts from sales of crops, some smallstock, animal fodder, petty trade (by both male head and his only wife), and farm labour (by the male head but also his wife on her friend's field). The farmers' wife makes an important cash contribution (from market trading, cooking 'gallettes' and 'soumbala', domestic work of fetching water and washing clothes for other women) and these are used to buy household essentials and to make loans to her husband for farm inputs. Hidden in the balance were subsistence crop yield, barter exchange, cash loans, gifts, grain, and manure from kinspeople, other women and merchants. Cash expenditure was for household essentials, wood, petty trade (kola and cigarettes), medicine, occasional investment in sheep, taxes, taxi travel to Niamey and markets. Hidden costs included labour exchange by the male head (on another farm) in return for manure, ceremonial gifts, and chickens and other gifts to family in return for transport and the income from the son's work in Nigeria. Most cash and non-cash expenditure was derived from social capital, which suggests that this household was vulnerable at the time of study.

[7] Transport to Niamey costs 1000 f CFA return and to Hamdallaye costs 2000 f CFA return. Average farm labour income is 250-500 f CFA/day.

(c) Case Three

The last example is a Fulani household. The immediately noticeable difference from the earlier cases is the positive cash balance, especially the large contribution from the women. Cash income from the male head comes from some cash-crop sales, livestock breeding and sale, Djerma payments for livestock care, and manure exchange. While his cash balance is negative, the male head would be able to reduce his livestock assets if necessary. Furthermore, many of his sources of income are hidden, such as loans from Djerma, customary exchange and barter (e.g. manure contracts), subsistence crop yields, and gifts from family (including his sons who are away with herds). His wife and children have a vital role. Their positive cash balance comes from the sale of NR-products (e.g. hibiscus, groundnuts, grass mats, spices - girls collect these for 'sauce de terre'), livestock breeding and the sale of products (often between family members) (e.g. chickens, smallstock, butter, milk), and jewellery. The income is seen to be much larger when non-cash barter exchange is included. Cash was spent on consumables, taxes, medicines, luxuries, grain for planting animal fodder and veterinary bills. Hidden costs were manure for animal fodder, NR-products (e.g. extra animal fodder, wood for making beds to sell at a profit), grain to the landowner and village chief, ceremonial livestock, gifts to non-family (investments in social capital), and gifts to family (e.g. money to son to go to school, chickens, eggs). This household has a diverse portfolio and is capable of farm investment, high manure input, rapid access to cash sources, and there are many social inputs into the household economy.

7.3.4 Mechanisms of the traditional exchange systems

Within the village, information on market prices and qualities of the goods, for example crops, was limited and had a skewed distribution. However, cheating and unfair deals were held at bay because the buyer and the seller generally belonged to the same social group and because exchanges were frequently repeated. Except in periods of scarcity, when monopoly pricing became possible, bargaining was often limited to the difference between what the seller could achieve in larger markets and what the buyer would have to pay there. However, in larger markets competition does not always protect the buyer and there is little social retaliation to regulate unfair deals because the traders have come long distances (for example, traders who use road haulage to transport maize from Mali during the dry season). The informal market for NR-products, therefore, worked best for households within the local economy.

The traditional exchange system in both NR and non-NR household strategies was based on individual trust. Trust must operate where the formal system does not work or where it is out of reach. Trust can either be ascribed or earned (Humphrey and Schmitz, 1996). Ascribed trust among family members is considered very important for building networks. However, it can also be problematic, because family members often feel that they are entitled to a share of the profit and, therefore, cannot always be trusted to return borrowed resources. People in Fandou Béri did not automatically employ family members in business outside of farming and therefore had often to rely on earned trust. However, in an unstable, risky environment without social security, insurance or the possibility of legal redress, this form of individual trust has its limitations. It does not work well if a business partner is dishonest, or if the individual is hit by illness, theft, bad harvests, fire or some other incident (see section 6.2.2.5). Hence there are limitations to social networks between equals. The networks may be some safeguard against small individual accidents, but not against wider failures, as in drought or national economic crises, which hit everybody at the same time (Fafchamps, 1992). Faced with this situation in 1997, many people in Fandou Béri had to rely on a rich patron for support. These hierarchical patron-client relations played an important role within Fandou Béri, in spite of their high costs. Villagers see a parallel in these relationships to NGO and donor roles, which create a problem for NGOs trying to bridge the gaps between small, medium and large service providers.

7.3.5 Natural resource products

Table 7.2 shows there were many natural resources (NR) uses besides those used to produce cereals. Plate 7.1 shows woodfuel for sale in Fandou Béri, which was the main source of domestic energy. It was also the main source of energy in nearby towns, including Niamey (where most of the wood gathered in Fandou Béri was sold). Based on daily firewood consumption of 0.8kg wood per capita, which has been estimated for the population of Niamey (Projet Energie II, 1991), a total of 500,000 tons of firewood was consumed in Niger in 1990. Firewood consumption in Niamey increased in the last decade by about 3.2% per year, which is very close to the annual increase in population since 1977 (Feil and Lamers, 1996). *Combretum* species were preferred for firewood in Fandou Béri, as in other Sahelian countries (e.g. März, 1993 in Burkina Faso), because it burns slowly, provides a hot fire with little smoke, is easy to spilt and dries quickly.

Plate 7.1: Household woodfuel for sale

Plate 7.2 shows the sale by household members from Fandou Béri of other NR-products, including domestic utensil and bowels and bags of crop residues. Both Speirs and Olson (1992) and Feil and Lamers (1996) noted the rising market value of crop residues and cut tree leaves (*F.albida* is preferred) with the gradual loss of rangelands, particularly in the vicinity of urban centres. An ICRISAT study in 1992 found that 20% of millet crop residue in rural villages around Fandou Béri was taken to market. Harvested crop residues can easily reach 10 f CFA per kg when transported to Niamey market, and thus provide an important source of income for farmers in Fandou Béri (see also Baidu-Forson, 1994; Lamers *et al.*, 1996; Larbi *et al.*, 1999).

Plate 7.2: The sale of homemade domestic goods and bags of collected fodder weeds at a local market

7.3.6 The problems in defining rural households

The complex process of maintaining a livelihood makes the definition of the activities of villagers in Fandou Béri very difficult. Bryceson (2000) identified a 'negotiating complex' or 'livelihood endurance' as a configuration of specific agents, their resource base, asset holdings, bargaining positions, objectives, investment stakes and fallback options. If this is so, then the definition will indeed be difficult. This is primarily because household diversification requires greater mobility. The analysis from this present study illustrates how the notion of a rural-urban dichotomy in household definitions, as has been so central to the international financial institutions' rationale for implementing structural adjustment, must be challenged. In addition, the dichotomies of male and female are challenged by economic exigency as revealed by the village case studies (see section 6.3). Other observers find this pattern elsewhere in dryland Africa (Iliya, 1998; Madulu, 1998; Mung'ong'o, 1998).

The villagers' involvement in continual negotiations over access to productive resources (i.e. land, labour and cash), and the demands on their labour for off-farm work within the wider framework, has raised the amount of risk they must shoulder. Bryceson (2000) claimed that this extra risk had increased the instability of rural people's livelihoods in Niger. Villagers have an enigmatic dual character as both partially autonomous and highly vulnerable producers. Their vulnerability derives from exposure to external market fluctuations, declining terms of trade and state taxation, which is often unrelated to their ability to pay. Nonetheless, they exercise partial autonomy by virtue of their subsistence production and their circumvention of land and labour markets through the use of village and family labour.

7.4 Conclusions

The analysis in this chapter has illustrated how farming in Fandou Béri is a product of social context. Firstly, while macro-economic policies and laws are often beyond the immediate experience of poor and excluded people, that does not make their influence less important. These include the influence of governance and law, macroeconomics and policy, the market and the private sector, informal institutions, international aid and research, labour and the informal sector. The effects of changes in this environment influence a household's capital assets and therefore, the household's options for investment in NR management (especially soil fertility and conservation).

Secondly, this means that understanding agricultural management practices and investment requires insights into the non-farming component of rural livelihoods. This requires an explanation of how institutions mediate agricultural change, and shape the ways in which actors access, use and derive livelihoods from environmental resources and services. This process has helped to contextualise the diversity and household differentiation seen in Chapters Five and Six.

For example, the potential productive capacity of households in Fandou Béri has many times been reduced by the shock of change in the wider framework. Labour investment has to be redirected in a rapid response to shock. Where cash cropping with fertilisers had been seen as an important strategy for the household economy during the 1980s, the mid-1990s required the whole farming system to be transformed to alternative sources of income or to cropping, with organic inputs. The locally weak cash-economy continued to depend on livelihood diversification into the informal sector and investment into livestock. Although livestock were vulnerable to droughts, households saw them as a form of savings and a source of security, to be sold at times of difficulties for profit. Their manure was also a valuable form of farm input even if it had meant that more land had to be assigned to fodder crops. Chapters Five and Six describe the popularity of cowpea as a crop (for animal fodder, cash sale and fertility improvement) and showed that fallowing was no longer seen as such a viable overall solution to fertility management (because of increasing population pressure and the risk of conflict).

The changes within the wider framework also explain why investment in non-NR activities, such as circular migration, petty trading and small businesses, remains common in Fandou Béri. The importance of the position of Fandou Béri in the hinterland of the Niamey cannot be underestimated, for the capital provides many market opportunities. The flexibility of the informal sector in Niamey provided a rapid means of raising cash seasonally and during times of difficulty. This kind of investment in activities outside farming makes the definition of 'households' in Fandou Béri problematic. State and market influences have permeated the society and the nature of the farming family and 'village community' has altered. The situation of many members of the sample families in Fandou Béri was in rapid flux, as they disappeared and reappeared on small-scale trading trips and took part in 'circular migration'. As Bryceson (2000) wrote, many rural people in hinterland communities in sub-Saharan Africa have changed their relationship to the soil, becoming multi-occupational, straddling urban and rural residence and flooding the labour markets. Consequently, the meanings and values that villagers in Fandou Béri attach to space and location are increasingly dynamic.

Farming practice, the production system, and the local economy have all been sucked into the edges of the whirlpool of the world economy, moving in response to the pull of capital. No real development can be achieved within villages, like Fandou Béri, without this. Structural constraints, which contributed to low levels of *per capita* income among the majority of the farmers in Fandou Béri, did not just reduce the rate of savings but also reduced the rate of investment. This chapter has shown that any strategy for agricultural development in the village will have to take into account the linkages between the agricultural and non-agricultural components of livelihoods. National policy needs to favour rural investment by providing incentives and appropriate technology. If NGOs continue to avoid hinterland communities in favour of more 'rural' locations, there will be an increasing need for some state support in the peri-urban zone, even if this is contrary to the IMF's views on market-oriented economic reforms. Any attempt to revive capital accumulation in Nigerien agriculture on a 'sustainable' basis must include plans to stimulate the capacity of the public sector to provide the complementary inputs in public goods, as well as to improve financial investment in agriculture. Alone, low-income farmers, such as those in this study, are incapable of boosting that investment.

The government's recommendations for increased rural productivity focus on the availability of resources (rural infrastructure and markets) and on making them accessible through monetisation (credit markets, non-farm income). However, making capital more available and accessible is too narrow an objective in the light of the dynamic nature of land use and investment and environmental change shown in this study. Furthermore, if agriculture is to be more formally integrated into the informal and financial sectors, the 'capital' flow of investment and labour resources into it will have to improve appreciably. This chapter shows how Fandou Béri has remained able to adapt to changes in the wider framework, at the local-economy and household-economy level, by developing links between the cash-economy and the customary exchange system, informal local networks and institutions, hierarchical systems of credit access and local market specialisation. Non-cash transactions and 'capital' substitutions are critical to farm investments. Different socio-economic groups of households had different capacities to capitalise on their endowments (ensuring entitlement). The dynamic nature of the household 'seasonal situation' produces critical moments for farm investment. The present analysis helps to explain the need for multiple livelihood strategies and diversity in farming practice. Moreover, informal institutions (or social capital) were seen to be used and developed by rural households to complement the cash-based system. For example: with the increase in land that is being cultivated, the borrowing of land is an optimal solution to the problem of over-cultivation on one's own land; as field units have been getting smaller, networks are increasingly used to access land; the greater involvement of women in the financing of agriculture, their natal ties are used to access resources for conducting agriculture; networks are used to access new technologies; as Fulani have settled on village territories, new forms of networking are created to allow the rearing of livestock; and as cash needs become greater, ways of networking to access cash are being developed.

8
Reflections on methodology

In keeping with the iterative process that this research adopted from Grounded Theory, this short critique chapter reviews the theoretical research framework (mainly the Sustainable Livelihoods framework) and the fieldwork process.

8.1 Observations using the Sustainable Livelihoods framework

The Sustainable Livelihoods framework (SLF), as reviewed in section 2.3.1 and 3.3, has been a useful approach for framing questions, and for organising different types and scales of information about the livelihoods of villagers in Fandou Béri (as explained in Chapter Three, section 3.1 and 3.3). It has provided a guide to placing data in a cultural and historical perspective, by allowing the inclusion of linkages between transforming structures and processes, non-agricultural factors and the vulnerability context (section 6.1 and Chapter Seven). However, certain theoretical blind spots and internal inconsistencies within the approach have become apparent.

8.1.1 The fluidity of capital substitution

The partitioning of 'capitals' in the SLF, was identified very early as a limitation. The household case studies, presented in sections 5.4, 6.3 and 7.3, show the fluidity of 'capital' substitution by farmers in Fandou Béri, as part of the flexibility they need for their management for farms and livelihood strategies (see Chapter Five). Households' dynamic portfolios of capitals were constantly changing and continuously being renegotiated and transformed.

Furthermore, by dividing economic and social structures in the SLF model, analysis of the exchange between the economic (cash-based) and non-economic (social) capitals is made difficult. The personal narrative of villagers in Fandou Béri suggests that some capitals are reducible to neither the 'economic' nor the 'social'. Instead, there is a continuous mixing between cash and non-cash structures in the local economy (see section 7.3), which directly influences households' livelihood strategies for coping with land degradation, environmental change and socio-economic change (i.e. their decisions for resource allocation and investment). Thus, the SLF was not open to variable cultural constructions and valuations of nature, which influence people's decisions about soil investment (see section 5.4).

The idea of 'social capital' in the framework does little to direct attention to systemic sources of power, nor can it be used as a tool to understand that the 'economic' is only valued as a result of the 'cultural' and the 'political'. This study found that differentiation and disadvantage, power and conflict, as well as co-operation and trust, were vital to the functioning of patterns of resource allocation and soil fertility investment (see sections 5.4, 6.2, 7.2 and 7.3) and yet had little place in the SLF.

8.1.2 All capital is social

In this study it appeared that all 'capitals' were filtered through the social context (see also Bourdieu, 1986 and Fine, 2001). The concepts of access and entitlement are thus critical to any understanding of individual investment in natural capital. For example, Chapter Five identified the relevance of individual identity, power, perceptions and visual geographies, while Chapters Six and Seven identified the importance of networks and the capacity of individuals to access resources when making investment decisions (the difficulties in defining social capital are discussed in 8.1.3). This evidence raises two key observations in relation to the 'Sustainable Livelihoods' Framework.

First, although the SLF has much in common with rights-based approaches to development (those that stress the importance of improving political, social and economic rights) (Neefjes, 2000), it fails explicitly to take account of the process of entitlement in resource allocation and use. It is not clear how rights-based analysis is to be incorporated in SLF research. For example, the 'capitals' in the SLF represent an endowment, which may or may not be used. A household's endowment of capitals can only bring positive benefits if it can claim them or if it can affect their right to make use of them (section 2.3.1; Sen, 1981; 1984; Leach *et al.*, 1997; Scoones and Wolmer, 2000; Neefjes, 2000). This means that the existence of a 'capital' in a household's portfolio, whether social, human, physical, or natural, is not enough to ensure farm investment, even if its quality is high. Legal rights to 'capitals' are important but in themselves are not sufficient to ensure improved livelihood strategies (e.g. in tenure laws, see section 7.2). Individual people, households and certain groups or classes of poor and vulnerable people must actually access capitals in order to turn endowments into real livelihood and environmental entitlements through their knowledge, skills, and in particular the social institutions that mediate their claims (as identified in sections 5.4, 6.2.1 and 6.4). The flows of investments for these different groups were presented in section 6.4.

Second, the diagrammatic framework of the SLF fails to account for the power relations that are inherent in all these processes. For example, Chapter Seven showed the relation between policy, identity, tenure systems, market pricing (sales and inputs), decentralisation and the power of social actors in Fandou Béri. Peet and Watts concluded in 1996 that there should be more politics in political ecology and Neefjes (2000) argued the same in the case of the SLF. As an analytical tool, SLF pays direct attention to policies, but it fails to emphasise that policy processes are all deeply political. Putzel (1997) argued that conceptualisations of social capital and civil society[1] have largely ignored the state's role in creating enabling conditions for social trust. Although the approach argues for empowerment and participation, power and trust cannot be represented as capital; and anyway how would they then be measured?

8.1.3 Problems in defining social capital

Social capital is the most nebulous of the concepts of 'capital' asset. Indeed it has been very critically reviewed and debated (Bebbington, 1999; Mehta *et al.*, 1999; Röling and Jiggins, 1998). There is a wide array of interpretation of the term.

[1] 'Civil society' is defined by Fine (2001) as the interaction in societies between the family and the state, creating social groups, and it is required for social cohesion, stability and welfare.

Woolcock and Narayan (2000) suggested that there had been four broad approaches to social capital: communitarian (focusing horizontally on associations), networks (as horizontal in the form of bridging and bonding, good and bad), institutional (good governance), and synergy (horizontal and vertical or linking in which the state is important). They advocated the use of the term only in respect of the last. However, much of the social capital literature argues for the superiority of horizontal over vertical ties. It sees horizontal ties as more altruistic, open and democratic by nature, compared to the vertical ties of family and clientele networks, which are characterised as exclusionary and less accountable in the wider society. This literature sees the trust embedded within social capital to be cumulative and path-dependent, bringing about a virtuous cycle of citizens' relationship to the state and the market. This is in contrast to the path of the vertical, exclusionary clientelist supply of goods and services, which can generate widespread societal distrust and economic and political corruption (see Bebbington, 1997; Durston, 1998). While horizontal ties were evident in Fandou Béri, vertical ties continue to be important through patron-client relations bringing credit, farm inputs (see case studies 5.4, 6.3 and section 7.3) and tenure arrangements (section 7.2).

Based on the evidence from Fandou Béri, the current concepts of 'civil society' and the horizontal ties in 'social capital' must be applied with caution. The terms are normatively defined and highly prescriptive, and may run counter to the real pattern of the internal organisation of rural societies. Putzel (1997) challenged the view that horizontal ties escape exclusionary practices, since most are based in one form or another on a group identity that distinguishes 'outsiders' from 'insiders'. Sometimes, such group identity is formulated on the basis of fictitious kinship, something that is prevalent in Fandou Béri. Durston (1998) argued that vertical ties were the basic building blocks for creating more democratic horizontal associational ties (i.e. synergy). Bebbington (1997; 1999) and Bebbington and Perreault (1999) reasoned that the 'capitals' approach needed to be reconnected to culture, linking power and conflict to sustainability, access and livelihoods. Narayan (1999) also acknowledged the frequent tensions between social and individual capabilities that can lead both to social exclusion and civic engagement (e.g. fodder rights and grazing, land conflicts in Fandou Béri). More clearly representing and analysing (see section 8.1.4) these linkages in the SLF is essential because social processes underlie valuation. However, many donor agencies, including the World Bank, continue to use Putnam's (1993) interpretation of social capital (as the associational ties built on the horizontal cultural norms of identity, trust and reciprocity), where neither the emotional ties of family nor the vertical authoritarian or patronage networks of trust or reciprocity count as social capital.

8.1.4 The challenge of analysing social capital in interdisciplinary frameworks

Both Grootart and van Bastelelaer (forthcoming) and Fine (2001) have pointed to the difficulties in measuring and analysing social capital. It is especially challenging when social capital is confined to the role of an investigative tool, whose purpose is little more than to guarantee that the social, however understood, is analytically incorporated. In the present study, it has been useful to use the idea of social capital to understand intra-household resource allocation, but the study has also illustrated how challenging it is to obtain 'hidden' social data (for example, to balance household budgets, see section 7.3). The challenge here is to establish trust with informants and verify the reliability of the data (see section 8.2).

While the SLF approach is interdisciplinary, its application raises analytical problems in comparing data, especially social capital with the other capitals. For example, this study has shown that the poor have little financial capital, but not necessarily little social capital, although it is difficult objectively to compare these data. There is a risk that in attempting to be useful to such a wide range of disciplines, the SLF model overlooks some of the complexity and diversity in individual strategies (as seen in this study).

8.1.5 Retaining a focus on the environment, economics and labour for soil investment

There is a growing body of work on the relations between knowledge systems and social capital (Röling and Jiggins, 1998; Bebbington, 1999; Mehta *et al.*, 1999; see section 2.3.2). However, not all differentiation between households can be labelled as social. Arguments about the meaning of 'the social' (section 8.1.3) should therefore not deflect the focus from one critical point that this study has found: the poor in Fandou Béri lack sufficient capital to afford them choice. The SLF was designed for policy as well as research, and it has been used to push for solutions that develop choice and build social capital. The SLF sees social capital as a means of providing an enabling environment for increased productivity or the conservation of natural capital. However, here too, this study found problems in practical terms. First, social capital is context-specific, hence the need for an assessment of household differentiation and needs. Second, social capital is a conceptual artefact that cannot be applied in the framework without questioning why there is economic differentiation (as set out in section 8.1.3 and 8.1.4). Thus, the evidence from Fandou Béri has shown that to promote a cultural construct like 'social capital' is alone not a means of alleviating economic differentiation and low investment in soil, and as Fine (2001:199) points out, 'development cannot be built out of anecdotes, metaphors, or heuristic devices'. The idea that an external agency could or should intervene to promote social capital formation echoes some of the ideology in the 'modernisation' school, particularly the advocacy of building horizontal ties and scaling up these ties to state and market forces.

Nonetheless, on a more positive note, the thickening of social capital is believed to generate improved civic leadership, better information flows within and between networks, more democratic interaction and efficient local economies. Thus, investment in social capital within the rural community is seen as a way of improving the access of individual actors to resources, while at the same time, paving the way for a 'sustainable' enabling environment (Singh, 1999). Yet this perspective, and its accompanying terminology, may be too optimistic for Fandou Béri. The emphasis on the building of 'social capital' may be counter-productive, for it could be seen to represent donors' attempts at making do with declining physical resource transfers, rather than being reflective of the real needs of rural dwellers. This suspicion is re-enforced by the perception that it is also a cheaper approach than focusing on cash, labour or bioproductivity constraints. An emphasis on the enhancement of social capital can be seen as mere tinkering with the symptoms of labour displacement in response to investment in off-farm and non-farming activities (e.g. livestock, petty trade, etc), without acknowledging or facing the real challenges. It is easy to be cynical about the World Bank's wish to 'build social capital' within frameworks such as the SLF. Is this only a justification for intervention in 'civil society', where development is seen as the result of non-market responses to market imperfections (reinforcing the dichotomy between economic and non-economic capitals)?

More important, what would be the impact of external organisations formalising existing social power structures and poor farmers' choices, given that there was evidence of dynamic social support in Fandou Béri based on kinship and vertical client-based ties (see Chapter Seven and case studies in section 6.3)? For example, the failure of attempts at intervention in Fandou Béri have shown that the introduction of new resources (e.g. inorganic fertilisers) may lead to the revaluation of existing ones (e.g. organic manures), and actually narrow the resource base, generating intensified resource competition (see section 5.3). The removal of fertiliser subsidies lead to greater innovation with organic inputs and an increase in specialisation and co-operation (section 7.3), but a widening in the differences between types of flows of farm investment between poor and rich households (Chapter Six). Labour displacement becomes the problem for those poor households already constrained by labour shortages, and increasingly needing to use labour-intensive green manures. Since this study showed the critical role of labour in household differentiation and farm investment, capability enhancement and appropriate technology is vital. Thus, human capital is a more critical problem than social capital (although access to improving human capital means individuals realise their entitlements to social capital) (see sections 6.2.2.5 and 6.3).

8.1.6 Enigmatic dichotomies in rural dwellers' livelihoods

The SLF was designed for 'rural' livelihoods (see section 3.3), building on a conception that there is a rural-urban dichotomy. Castle (1998) even offered the notion of 'rural capital' as a form of social capital in the countryside. This study has demonstrated that the pure rurality of livelihoods in Fandou Béri and elsewhere in West Africa, cannot be taken for granted (see case studies in sections 6.3 and 7.3). The reality is a rural-urban continuum in which many so-called rural dwellers conduct their livelihood strategies. However as Chapter Five showed, using the SLF highlights dichotomies in household linkages and support networks, such as those based on hierarchical and ascriptive relations, which are embedded in differences in age, gender and genealogical descent.

8.1.7 Difficulties in identifying and labelling households using framework criteria

Soil management does not develop in a deterministic way and it is difficult to make typologies for networks, values or any other socio-economic characteristic that influences resource allocation (Chapter Five). The household situation is dynamic. It is difficult to categorise a household situation at any one point. Endowments are constantly changing and entitlements constantly being reworked (the relationship to fieldwork data collection is discussed in section 8.2). It is impossible to find social norms when multiple paths are followed (see sections 6.3 and 6.4). This study showed that while it is difficult to define livelihood decisions or poverty based on natural resource holdings alone (including soil fertility), it is even more difficult to establish how best to see the differences between households. Wherever difference or inequality is to be found in the case studies at Fandou Béri, it can be theoretically embraced with the 'Sustainable Livelihoods' framework as a structure of independent but linked components, yet this study showed the difficulty of labelling households with discrete, easily defined criteria, for they provide a misleading basis for identifying the poor (if nothing else) (see Chapter Six). For example, a small land holding is shown to be a poor criterion of poverty. A detailed knowledge of households is needed if ostensible wealth indicators are not to be misread. The difficulty in identifying households suggests that instead of basing intervention on the criteria used in the SLF, it would be best to include a process of self-selection by farmers to specific help based on farmers' specific interests and time availability.

8.2 Critique of fieldwork process and practice

A detailed review of the methodological theory and the fieldwork process and practice was presented in Chapter Three. This section identifies the primary shortcomings of the study's fieldwork methodology, summarises the actions that were taken to minimise these problems, and outlines possible improvements in the mode of fieldwork, with the benefit of hindsight.

8.2.1 Addressing difficulties in fieldwork methodology

The following points were identified to be working difficulties in the fieldwork:

- A risk that a small sample of households would not accurately represent local patterns and processes in natural resource use.
- A risk that misuse of questionnaires could emphasise power structures, with socially important or older individuals dominating conversation and skewing the data.
- A risk that data will be unreliable when: (a) people are discussing the past (either because they have 'fond memories' or because they have rationalised an action in retrospective thought) (e.g. 'the soil was better when I was young'); (b) people are discussing aspects of their livelihoods in which they believe the researcher could intervene (e.g. 'cash is a problem'); or (c) when people tell you what they believe you would be interested in (e.g. focusing on cash-based products).
- A risk that fieldwork design reinforces the researcher's assumptions about natural resource investment, through inappropriate structuring of questions and conversation.
- A risk that the local narrative will be skewed or lost when using a translator.
- A risk that research set within a short timeframe will not provide a deep understanding of livelihood portfolios or the decisions behind natural resource investment.

8.2.2 Action taken to minimise these fieldwork difficulties

- Although the sample of farmers included in the study was small (twenty households), it had been carefully selected by the SERIDA project to cover a cross-section of the population differentiated by economics, status and age (for more detail, see section 3.4.1). The aim was to collect detailed information about each household, providing a better understanding of the specifics in household differentiation, especially resource allocation and soil investment.

- Self-selecting focus groups of farmers in Fandou Béri were used in 1997, and the experience drawn upon to establish an environment that did not intimidate individuals, thus maximising the farmers' interest and participation. Farmers were most candid during individual meetings or with family members on the farm and therefore on-farm individual meetings were planned. My time in the village in 1997 also raised my awareness of individuals' role within village social structure, with whom they might discuss meetings (information flows) and any ulterior agenda they might initially pursue.

- Unreliable data was minimised through detailed verification processes (cross-checking data with different sources and using different methods, including observation, see section 3.4.2) and establishing trust with individuals (an openness to the limits of the research and purpose of my time in the village – 'to learn as a student'). An effort was made to re-familiarising myself with the farmers' fields and social or political structures. The difficulty in using local narratives about the past was acknowledged during data collection and was addressed in Chapter Five (section 3.2). Addressing the potential for some responses to be rationalisation of an action was more difficult, and could only be minimised by keeping a broad overview, repeatedly discussing the topic in different ways and to compare and question responses.
- Semi-structured questionnaires were used only to collect key information in the early stages of the fieldwork, relying on more engaged methods of data collection in the later stages, such as visualisation, participant observation and on-farm in-depth discussions (section 3.4.2). 'Open' questions were included in the questionnaires to allow the informant to introduce ideas (see Appendix 2). In later questionnaires, questions served only as themes or guides for debate, usually in combination with participant observation or mapping. Open-mindedness to these debates allowed me to gather and critically assess the information about individual farmers' perspectives. This meant the inclusion of topics that were important to farmers, however apparently unconventional they were to orthodox science. The process involved moving beyond limited assumptions or cultural blindness, developing trust and experiencing the farmers' world of everyday experience and knowledge (known in Djerma as *berey*). Metaphoric linkages and symbolic interactions in mundane activities in the discourse were sought out in order to understand better the local decision-making process (see Chapter Five). For example, farmers saw 'common knowledge' as assumed knowledge held within and belonging to their culture and community, which was considered lacking in

originality, and therefore, was not initially worth discussing in their opinion. All the field methods were subjected to early trials with both focus groups and individuals (not included in the sample) (section 3.4.1). From these trials, the most popular techniques with farmers were identified and the layout of questionnaires and forms could be improved. The results of the trials were compared to the opinions of the farmers in the sample to establish if those farmers connected to SERIDA gave responses primed by previous questionnaires (of which I had copies). These issues could then be addressed in analysis.

- The role of the translator and field assistant, Siddo Seyni, was discussed in section 3.4. He had worked for international research projects in the area and had received some training (i.e. he was prepared to translate and not prompt or interpret views). He understood the objectives of the project and contributed to written reviews and progress reports throughout the fieldwork. He was a popular local Djerma man from Hamdallayé, aware of local politics and cultural rules, but removed from any village power relations. As a jovial character, he was able to lighten initial anxieties and suspicions by farmers about my activities in the village, but he was also articulate enough to establish farmers' interest in serious debate.

- The dangers in forming an opinion about the seasonal situation of the households with snap-shot data and handling participatory data that were not gathered over long timeframes were acknowledged and discussed in Chapter Three and Chapter Five (section 5.4). Measures were taken to maximise the reliability of the information (section 3.4). Firstly, because Fandou Béri had been the subject of investigation for my NERC-sponsored Masters in Research (Environmental Sciences) on indigenous knowledge, fallow systems and indicator species, I was aware of most subtle political and cultural issues, and able to compare findings in 1998 with those in 1997 when I had established a good rapport with the some of the villagers. The villagers were aware of my role as a student and remained determined that I should learn about farming and life in Niger, offering encouragement while learning to speak Djerma. They told me that they did not compare my role to those of previous researchers and scientists in the area and thus felt less intimidated and more likely to discuss their opinions and situation. Secondly, because the objectives of the study were to understand resource decisions, based on capital assets and ability to enact entitlement at a particular time of the year, it was considered that the period from April to August remained the key time period for these decisions (according to the villagers). Thus the fieldwork period covered the main part of the growing season when farmers were making investment decisions, and migrants were returning to the village to farm (see 3.4.2). By August, the allocation of land was complete for 1998. Finally, I believe that my study of household 'capital assets' at a point in time, when combined with the cultural and historical analysis, has uncovered the essential feature of the portfolio that the household, and individuals within it, are basing their decisions and resource allocations upon. This longer timeframe was addressed using SERIDA data, containing some oral histories from 1978 and more detailed information (including quantitative data) from 1996-1998. I acknowledge that while the accumulation of knowledge through fieldwork experience gives an insight on another culture, it does not guarantee deep comprehension. Social anthropologists will continue to equate deeper 'readings' of the relationship to land to deeper experiences of the world. For Ricoeur (1979:100), 'the meaningful patterns which a depth-interpretation wants to grasp cannot be understood without a kind of personal commitment similar to that of the reader who grasps the deep semantics of a text and makes it their own'. Many would argue that the deeper reading of everyday choices requires long-term immersion in both language and social rules (Stoller, 1989). However, commitment of this level takes years and is therefore beyond the expectations of this study. To compensate, readings of everyday experiences and 'common' knowledge were balanced with critical observation.

In retrospect, it would have been beneficial to conduct further analysis on: household economics and the impact of diversification on decisions for labour and capital investment on the farm; short-term and long-term migration; and nutrient balances for each field on the study farms. Further points of investigation are discussed in Chapter Nine (section 9.5) as issues for the future sustainability in Fandou Béri. Ideally, a larger sample, including more Fulani farmers, would have been taken, along with a comparative study in another village (the study compares Fandou Béri to other villages in section 9.1). In addition, this research should best have been conducted over successive seasons to compare decision-making under different rainfall regimes and establish patterns of land use change and capital assets, especially those assets enabling livelihood enhancement. However, a sequence of events occurred that required the fieldwork process to be modified. While I was in Niger in 1998, it became clear that analysis costs for nutrient analysis would be too high to obtain funding. This would have been realised had a pilot study been afforded but instead a great deal of flexibility was required, and the objectives had to be refined in the field. The SERIDA project completed its 1997 research phase but then failed to secure funding to continue to monitor the study village and ceased to operate in Niger. This caused a breakdown in logistics, and anxiety amongst villagers, straining working relationships. The closure of the project followed an international and national trend by academics and development workers in the region at the time. During the 1998 fieldwork season, Niger's political instability continued, with one 'state of emergency', after military unrest, occurring in this period. There had been a military coup in 1996, and after I returned to the UK, another coup erupted with the assassination of the President in Niamey (see table 7.1 in Chapter Seven). The country slid into political and civil instability, economic support and aid were disrupted, and State welfare was withdrawn. The situation in Niger has since stabilised. However, the fieldwork difficulties and the increased personal risk of working in Niamey came at a time when I was making decisions about the future of the project. Consequently, it was decided the project should focus on livelihood strategies and soil fertility using the detailed information already collected, supplemented by the SERIDA database.

8.3 Conclusions

The Sustainable Livelihoods approach has been a useful framework for approaching this research, but only if its theoretical problems are acknowledged. These primarily reside in the concept of capital substitution, the role of social capital and its relation to other capitals in terms of the influence of power and access. The challenges of addressing these theoretical issues have been discussed with reference to the evidence from Fandou Béri of dynamic and complex livelihoods. Understanding these complexities makes for challenging fieldwork. The primary difficulties in the fieldwork process and practice, including sample size, timeframe and collection of reliable qualitative data, have been addressed and I believe that the problems have been minimised, by being flexible and by the through cross-checking of information.

9
Sustainability: context and conclusions

Much of the debate about rural sustainability in the West African Sahel has been based on soil fertility and farm investment, leading to continuing concern in the agricultural science discourse of the perceived linkages between population and livestock growth, agricultural intensification and productivity. Chapter Five provided evidence that intensification in is taking place within the village zone at Fandou Béri and that farmland is expanding into marginal land outside this zone. This process is compounded by farm fragmentation and is reflected by the decreasing productivity of the small fields in the village zone and decreasing fallow periods (Chapter Six). The consequences for subsistence production and degradation of resources, in particular of soil fertility, are of primary concern for agricultural science. Many changes have occurred in the conditions under which agriculture is practised: increased monetisation and market integration, livelihood diversification, a changing environment for customary tenure and exchange systems, a drier climate and rising populations of people and livestock (Chapter Seven). These changes are usually treated as further causes of lower investment, productivity and increased land degradation (Chapter Two).

However, this study has shown that there are many assumptions within the scientific narrative and has illustrated the value of understanding intensified practice using case study analysis. Framing agricultural practice within a holistic approach of sustainable rural livelihoods suggests a more complex local narrative at Fandou Béri than that offered by agricultural science. This is a story of a system characterised by potential as well as constraint, flexible management, inequality in access to endowments, multiple and dynamic trajectories of change, and by diverse livelihood strategies (Chapter Six and Seven).

Section 9.1 of this chapter places the patterns found at Fandou Béri within the context of research from other villages in the Sahel and dry sub-Saharan Africa (as set out in section 1.3 study objectives). The following three sections attempt to draw conclusions to the questions that were asked in Chapter One. They address farming and soil fertility management, diversity in farming, and multisectoral understandings of farming in Fandou Béri. Finally, prospects of sustainable agriculture, and further questions the study raised, are highlighted in section 9.5.

9.1 Fandou Béri in the context of African dryland agriculture

This section contextualises the observations from Fandou Béri by comparing them to other studies of villages within the Sahel and dryland Africa. While there are comparable patterns between Fandou Béri and other villages, there are also considerable differences in livelihood response, in population densities, rainfall regimes, soils, governance, and market forces. The study does not attempt to predict pathways of change for Fandou Béri on the basis of the results of these studies because the simple substitution of variables in the system cannot allow for the multiple response and spatial diversity seen at Fandou Béri.

9.1.1 Soil fertility maintenance at low populations using targeted organic manures

Examples from research in Burkina Faso, Nigeria, Mali and Zimbabwe (all with similar rainfed cultivation, poor sandy soils, low technology, and population density to those in Fandou Béri) illustrate how labour, livestock and capital constraints limit high-input technology and intensive practice. These farming constraints have pushed many farmers into developing and integrating organic manures into their agriculture, in an attempt to combat declining soil fertility (e.g. Hartemink *et al.* (1996) in Burkina Faso, Boeson and Friis-Hansen (1997) and Meertens (1999) in Tanzania, and Bosma *et al.* (1999) in Mali).

- In Burkina Faso the production potential is low because of limited annual rainfall (550-650mm/yr) and infertile sandy soils (Vierich and Stoop, 1990). Lompo *et al.* (2000) recorded the soil fertility practices of two villages in Burkina Faso, Thiougou (Mossi and Bissa farmers) and Kirsi (Mossi and Fulani farmers). Dugué (1989) and Prudencio (1993) reported a population density of 44 people per km^2 in this area, an increasing proportion of the area under cultivation, and a short fallow-rotation system. Prudencio (1993) found that nitrogen and phosphorus balances were in equilibrium for fields close to the homestead, but were in deficit on other fields. Nutrient depletion was found in Kirsi (Lompo *et al.*, 2000), in Bidi, a village in Oudalan Province (Krogh, 1997) and elsewhere in Burkina Faso (Asadu and Enete, 1997; Enyong *et al.*, 1999). Farmers in these areas maintained soil fertility using intensive conservation techniques, targeted applications of 'green' manures and some mineral fertilisers, but little animal manure was used (because of low livestock ownership). Intervention projects had introduced many of these intensive practices. It seem unlikely such intensive conservation practices, using technical interventions (also seen around Tahoua in Niger, Hassane *et al.* 2000; the Central Plateau of Burkina Faso, Batterbury 1998; Atampugre, 1993; also Roose *et al.* 1999) would be popular at Fandou Béri, given the current household constraints (section 6.2.3). Comparisons could instead be made between Fandou Béri and a study by Van den Elshout *et al.* (2001) of northern Sanmatenga District (20-40 people per km^2). As at Fandou Béri, they found that farmers were interested in intensification because labour was scarce. They argued that inorganic fertiliser could be used to reduce the labour needed to work the land and compost. However, without a secure market for cash crops, farmers could not use the sale of their harvest to recover the cost of external investments. Furthermore, not all farmers had a commercial interest in increasing output. As at Fandou Béri, agriculture was not seen as a good source of income and if they had time and cash, it was invested instead in livestock or off-farm activities.
- The Manga and Fulani, who managed extensive agro-pastoral systems of Kaska (11 people per km^2) and Futchimiram (31 people per km^2) in Yobe State, north-eastern Nigeria, have been studied by Mortimore and Adams (1999), Mortimore *et al.* (1999), and Harris (1998). The rainfall average in these areas was between 344 and 374 mm/yr (between July to September) between 1992 and 1996. Farmers

grew millet, sorghum, groundnut, cowpeas, and additionally in Kaska, date palms, and dry season garden cash crops. In Kaska, increased pressure on the fragile upland dune soils had led to increased areas of degraded land and reduced soil fertility. These change had been exacerbated by a 25-35% reduction in rainfall since 1965. Because of labour constraints, short fallow-rotation (less than 3 years) was the most popular practice. Many researchers have also drawn conclusions on the importance of fallow (Devineau, 1999; Akobundu *et al.,* 1999; Dakora *et al.*, 1997; Franzel; 1999; Sanchez, 1999). Carsky *et al.* (1999) showed in their study in northern Nigeria that a short-fallow can still increase yield to 365 kg per ha. The number of small ruminants have increased in both Kaska and Futchimiram, as elsewhere in northern Nigeria (De Leeuw *et al.*, 1996), because farmers prefer to use their manure (by corralling them near the village) (as at Fandou Béri, Chapter Five and section 6.2). However, Harris (1998) reported that farmers in Kaska did not collect or transport manure and household refuse to fields, and there were fewer donkeys than elsewhere in dryland Africa (Starkey, 1997). Consequently, most farms in Kaska had negative nutrient balances (Harris, 1998). Mortimore and Adams (1999) found positive nutrient balances on six farms in the village of Dagaceri in Jigawa State, Nigeria, which had Hausa groups living alongside Manga and Fulani, and a population density of 43 people per km². Rainfall here was lower than Kaska and Futchimiram but distributed over a longer growing season (between June and October). Although Dagaceri was more arid than Fandou Béri, the farmers had made similar decisions about cash cropping following periods of drought (as at Fandou Béri, Chapter Five). Like farmers in Fandou Béri, few choose to cultivate cash crops like groundnut or cotton, and have few incentives to invest in soil fertility maintenance (Harris, 1999).

- In central Mali, the small village of Dilaba lies 40 km away from the city of Segou. Dembélé *et al.* (1998) identified a rainfed agricultural system of millet-cowpea, large farms of up to 30 ha and a population density of 29 persons per km². While some fields close to the village had not been fallowed in the last twenty years, the cultivated area around the village had expanded. The soils had negative net flows of nitrogen, phosphorus and potassium. Farmers were dependent on organic manures, targeted to poor soils; they used their IK in this procedure (e.g. they used *Eragrostis sp.* and *Zornia sp.* as indicators of poor fertility). However, these farmers faces many difficulties: costly inorganic fertilisers and no market for cash crops; a shortage of grazing land for livestock; and high demand for crop residues, which prevented the recycling of nutrients. Dembélé *et al.* (1998) and Toulmin (1992) found farmers dependent on organic manures in Siguiné and Dalonguebougou, other villages in the Segou district. These villages had more land available for grazing and manure exchange arrangements with resident Fulani (as at Fandou Béri, Chapter Five).

- The Chivi communal area in southern Zimbabwe (Reij *et al.* 1996, Scoones 1996, 1997, Chuma *et al.* 2000, Campbell *et al.* 1998) had a population density of 45 persons per km². Farmers made use of the natural soil diversity (90% of farmers cultivate sandy soil, while 60% also had a field on loamy soil) to grow millet, sorghum, groundnut, cotton, sunflowers and maize. Homestead and village fields are managed intensively, receiving organic manures. Campbell *et al.* (1995) claimed that the fallow area was continually decreasing, but there was still limited access to dung, even after serious livestock losses in the 1991-2 drought. The farmers had responded to the negative net flow in nitrogen on all of their fields by focusing applications in niches that offered better returns or were perceived to be infertile. Likewise, positive phosphorus balances were maintained by the use of compost, ash, leaf litter and termitaria earth (farmers in Fandou Béri practice these techniques (Chapter Five), although the effect on the phosphorus balance is not known).

These examples show that farmers elsewhere in dryland Africa also use a flexible and diverse regime of fertility inputs, but there appears to be insufficient organic inputs available to sustain soil fertility in the long-term. Abubakar (1996) feared that a continuing reliance on fallow would lead to declining soil fertility. While farmers make greater use of local knowledge, and integration of smallstock is popular, it is unlikely that all farmers will achieve mixed farming. Given the evidence from Fandou Béri, household differentiation will remain. Furthermore, the system is everywhere subject to market forces, competition for crop residue use and the continued co-operation between herders and farmers (for access to animal manure).

9.1.2 Modelling trajectories of land use and soil change with population growth

Numerous studies have modelled land use and soil change with population growth, often with negative consequences (see Chapter Two). For example, Van der Pol

(1992) calculated that in southern Mali, 40% of the total income from agricultural activities was based on soil mining, or the depletion of the nutrient content in the soil of cultivated fields. Even allowing for generalisations, this level of mining would not be sustainable in the long-term. It is difficult to estimate such figures for Fandou Béri. Studies of the intensification process in Niger, which have resulted in models based on simple socio-economic and complex satellite data, also yield a picture of environmental degradation (Nagumo, 1992; Loireau, 1998). These models produced 'soil quality mapping units' to identify areas of potential degradation, differentiated according to landform and the overlying soil. A model by Amissah-Arthur *et al.* (2000), using GIS data to identify land use and soil change at Banizoumbou, Niger, close to Fandou Béri, is particularly relevant. The territory of Banizoumbou is of similar size to that of Fandou Béri at 35km² (63% under cultivation), and has a similar pattern of ring management (to that found by this study). This may be because the villages are of similar age and have developed in comparable ways. At Banizoumbou, a process of expansion into marginal lands was identified between 1986 and 1996, as at Fandou Béri and elsewhere in Niger (Ba (1991), for example, observed a pattern of expansion between 1950 and 1991 from 12% to 71% farmland).

However, while there appears to be some similarities in land and soil patterns between villages in southwestern Niger, problems arise when the models are compared to evidence from Fandou Béri (see Chapters Five, Six and Seven). First, the models base the decision-making unit on the 'individual' (selected from the use of census data). This deflects the argument from additional processes in society (kinship, household networks, tradition, trust and power), that have been found integral to understanding decision making in Fandou Béri. Second, the models see diversity of the system to be the result of environmental variation, but this ignores the history of land use, household or village interaction and the role of household economics on landscape management. Third, by using mathematical indexes to calculate land-use intensity, which are cited as 'easier to calculate' (Amissah-Arthur *et al.*, 2000:588), the real patterns of labour allocation are not understood. Fourth, by adopting singular trajectories of change and static concepts of carrying capacity, the studies find that the land use for a system based on fallow rotation is approaching saturation. This ignores possibilities resulting from innovation and differentiation. Finally, land pressure and declining productivity (the result of population growth and resource abuse) are cited as reasons for triggering male migration to Niamey, the Ivory Coast and Nigeria (Gorse and Steeds, 1987; Nagumo, 1992; Leisinger, 1995), but this argument fails to allow for a history of household diversification, the growth in the informal sector and infrastructure to Niamey, the influence of SAPs or the state on the price of inputs, the inadequacy in rural market outlets or the cash crisis common to many household economies (see Chapter Seven). Amissah-Arthur *et al.* (2000) concluded that fallow periods would have to be lengthened in Banizoumbou if degradation was to be prevented, but this is unrealistic given the current socio-economics and the opinions of farmers in Fandou Béri (Chapters Five and Six). Furthermore, as this study has shown, it is difficult to distinguish between variations in yield that are attributable to nutrient decline and farm expansion, or from those that are a result of fluctuations in rainfall. The importance of rainfall is underlined by the study of Leisinger *et al.* (1995), working in Niger. They observed that between 1969 and 1989 agricultural production and land farmed fluctuated from year to year in conformity with rainfall patterns.

9.1.3 Studies on the spatiality and diversity in intensification patterns

Studies of the spatiality and diversity of soil fertility management and their patterns of change with intensification in other villages can usefully be compared to those at Fandou Béri (see Chapter Six).

- GIS and ground-truthing by Turner (2000) in southwestern Niger found cropping patterns to be highly dynamic with significant inter-annual changes in the location of cropped area. Gandah (1999) investigated these patterns of spatiality in an intensifying agricultural system in southwestern Niger. He identified landscape position and distance between fields and villages to play a crucial role in soil fertility management. Fields located less than 1 km from villages were cropped continuously, receiving 3-17 tons ha-1 of manure by corrall rotation, while those over 2km away fields received very little input. This compares closely with the finding at Fandou Béri (see section 6.2.4). Another investigation in Maradi, Niger, by Issaka (2001) showed that there was a sharp increase in soil fertility under cultivation with manure inputs, bringing total nitrogen, phosphorus and potassium up to levels found in uncultivated fallow land. As for the Djerma in Fandou Beri, and elsewhere in Niger (Ayantunde, 1998), she found labour, manure supply, and transport to be the main constraints to the addition of organic inputs.

- Ramisch (1999a) found in Lanfiéla, southern Mali, complex patterns to nutrient loss which were related to household wealth and productive capacity, as found at Fandou Béri. Although he found a net outflow for nitrogen from the farms, losses increased from the lowest (-3.2 kg N/ha) in the village compounds to the highest (-21.4 kg N/ha) in the village periphery; while Fulani fields did not suffer outflow (+23.3 kg N/ha) (Ramisch, 1998). These patterns may be close to those at Fandou Béri.
- In Burkina Faso, Prudencio (1987; 1993) identified cultivated fields to be at least as fertile as old fallow, while Pieri (1989) showed that farmers used IK to decide when to rotate cultivated plots with short-fallow, preventing serious soil degradation. A study of villages in Burkina Faso by Mazzucato and Niemeijer (2000) also showed that cultivated fields had a higher fertility than uncultivated sites, especially in terms of N and P. Both Mazzucato and Niemeijer (2000) and Gray and Kevane (1999) argued from their evidence that management practice might be independent of population pressure in Burkina Faso, which challenges the assumptions in some literature (cf. Chapters One and Two). They believed that the diverse patterns of low soil fertility were strongly related to vegetation and rainfall changes, and not necessarily over-cultivation.
- Investigations into soil fertility in southern Ethiopia by Eyasu (1997; 1998) also found spatial variation in nutrient balances across different parts of the farm, and between households, based on differences in management of organic inputs. These patterns are very similar to those found at Fandou Béri (Chapter Six). The patterns of differentiation indicate the importance of comprehensive sampling in such studies. A study by Data (1997) in Kindo Koisha showed that there were 'zones of field use intensity' from the farm to the bush. The positive nutrient balances in the garden fields (locally known as *Darkoa*) indicate that farmers, and particularly poorer farmers, had adopted the best possible options. Beyond the outfields (locally known as *Shoka*) lay fallow plots, mainly used for fodder. Organic matter was rarely taken to the outfields and all crop residues and manure was focused onto the garden fields, mainly because of the lack of material and labour to transport it. With the fields, each soil was managed in a different way according to

its colour, depth, erodibility, capacity to hold water and how easy they were to cultivate (Ejigu *et al.*, 1995), patterns that are very comparable to those at Fandou Béri. While scientific classifications identified only one soil category for the entire district, farmers differentiated soils types (Data, 1997).

9.1.4 The relationship between population growth and technology

Traditional theories on agricultural intensification driven by population growth assumes that a system will continually replace technology to improve efficiency (i.e. replace the hoe with the plough) (cf. Boserup, 1972; Sanders *et al.*, 1998). However, several studies have shown this relationship to be more complex. Seur (1992), writing about Serenje District in Zambia, showed that agricultural intensification with increased populations density did not necessarily mean that the plough replaced the hoe when the shortening of fallow periods reached a certain threshold, with many farmers preferring to keep traditional technologies. Williams (1997; 1999) drew similar conclusions from studies into the use of different technologies in southwestern Niger. Even where there were labour constraints, he found that animal traction was not necessarily beneficial to smallholders because of the perceived cost and risk associated with keeping draft animals. Instead, he found that individuals responded in different ways to land scarcity and poor soils, and the choice and decisions that farmers made were dependent on complex livelihood structures and opportunities, with many farmers choosing to specialise their role (i.e. some farmers would keep animals for hire and social co-operation would improve). This role specialisation and co-operation was apparent at Fandou Béri. Consequently, social networks have helped to make the agricultural system more adaptable than intensification theories assume. The assumption of a single 'population density – technology' intensification path is clearly unhelpful. Instead, there are multiple trajectories for different farmers (Turner, 1995), as at Fandou Béri (see Chapter Six).

9.1.5 The relationship between the cash-economy, co-operation and agricultural investment

This section presents examples of research on social responses to the cash-economy, and reports how these responses have influenced agricultural investment. As at

Fandou Béri (Chapter Five), Neef (1997) observed the influence of the cash economy on manure contracts, an important agricultural investment, in his study of Djerma, Hausa, Fulani and Bella farmers in southwestern Niger. He found that only one quarter of the total sample surface of land was under grazing contract at the end of the harvest and those cash-based contracts that were in place had widened; organic matter was being concentrated on fields of the wealthy or the Fulani. In another context, and again in a pattern that has some resonance with patterns at Fandou Béri (sections 6.3 and 6.4), Stoller (1989) documented the influence of the cash economy on social organisation and power in Niger. For example, he found many nobles or individuals in the traditional lineages were in the embarrassing position of having to borrow money from merchants to maintain their social networks and to be able to make symbolic requisites of position, such as the giving of gifts.

However, these findings of Neef and Stoller can be balanced with examples (Howorth and O'Keefe, 1999; Mazzucato and Niemeijer, 2000) that show cash to be just a tool for social responses and co-operation in the field of agricultural investment. Mazzucato and Niemeijer (2000) argued that increased monetisation and market integration in rural Burkina Faso had not led to a complete overhaul of a previously existing system of exchange. Rather these changes had been incorporated into the system of exchange to form a mixed set of market and social principles that guide people's economic action and investment. Their findings have clear comparisons with the examples of co-operation that monetisation has brought to Fandou Béri (section 7.3). Howorth and O'Keefe (1999), reporting on the Mossi village of Sissili, also in Burkina Faso, identified a similar system of co-operation integrated into the cash economy, beginning in the 1970s when Fulani settled in the village. They found that there had been a process of increased specialisation by ethnic groups, which had intensified the exchange system, improved tenure co-operation and the relations within the local administration system. White (1990) and Turner (2000) also revealed a dynamic pattern of local land-use based on ethnic co-operation between Djerma and Fulani, as at Fandou Béri (see boxes 5.1 and 5.23, section 6.2.3 and Chapter Seven). Such a system has potential for conflict in farmer-herder interactions, as a result of privatisation of communal ranging lands and increasing fodder demands, yet little empirical evidence of an increase in conflict in southwestern Niger was found by Hussein (1996). This can be partly explained by the evidence from Fandou Béri (see boxes 5.1 and 5.23, and section 6.2.3) of closer inter-ethnic co-operation, resulting from the changes to herding contracts since the droughts in the 1970s. The Fulani at Fandou Béri are herding increased numbers of Djerma livestock.

9.1.6 The relationship between the non-NR component of rural livelihoods and agricultural productivity

Many studies have shown the negative and positive effects of livelihood diversification on agricultural productivity. Enyong *et al.* (1999) argued that low agricultural labour productivity was caused by the migration of young people from the rural areas in Burkina Faso, although long-term migration is less of a constraint at Fandou Béri (Chapter Five and section 6.2.3). On the basis of a bio-economic model that was run to the year 2030 for another village in Burkina Faso, Barbier (1998) proposed that such a reduction in the labour force would promote a return to a fallow management system. This seems an unlikely scenario for Fandou Béri, or elsewhere in dryland Africa (Mortimore, 1989; Kimmage and Adams, 1992; Reardon *et al.*, 1992; Snrech *et al.*, 1994; Rain, 1999; Hampshire and Randell, 1999), where off-farm diversification can prevent such involution, by acting as an important source of income. A study of villages in Mali and Ethiopia by Hilhorst and Toulmin (2000) reinforced the view that livelihood diversification could have a positive effect on agricultural productivity. They found that poorer households diversified to survive, while richer households diversified to accumulate, and that larger families were best able to manage labour allocation. These findings correspond closely to those at Fandou Béri (see figures 6.43 and 6.44, Chapter Six and section 7.3). Mortimore and Adams (1999) and Fafchamps *et al.* (1998) also provide examples of positive feedback (investment into the farm and livestock in villages in Nigeria). However, Shepard *et al.* (1998) and Bryceson *et al.* (2000) found evidence that household diversification could increase polarisation in farm investment between households. They found that some households diversified to invest in future business, while others diversified to support essential household food needs (see Chapter Five and Chapter Seven for discussion of similar patterns in Fandou Béri).

9.1.7 Evidence of integrated nutrient management for intensified farming at high populations

Some studies show village systems in the Sahel and other parts of dry sub-Saharan Africa which have been able to intensify their farming practice at high populations without leading to widespread degradation. While these studies are from areas with similar rainfall and poor soils to those at Fandou Béri, it is difficult to make direct comparisons between their villages and Fandou Béri because of differing local socio-economics.

- Tumbau village in Kano State has a population density of 223 people per km², farming on an average 4 ha farm (Mortimore and Adams, 1999). Average rainfall was 571 mm/yr between June and September for 1992-1996. Soils are sandy, acidic and well drained with low organic matter. Farms were intensively managed with a high degree of livestock integration (two thirds are smallstock). The principal soil fertility strategy was manure application but farmers also use 'green' manures, and apply straw, ash and household waste. Inorganic fertiliser was used but only for cash crops of groundnuts and peppers, which were grown in addition to millet, sorghum and cowpea. Farmers had not used fallow rotation since the 1970s yet, according to Harris (1996), the system was sustainable. Farms in Tumbau were more intensively managed than those at Fandou Béri, with farmers practising mixed farming, sufficient labour availability and a good market for cash crops, making the use of inorganic fertiliser cost-effective. However, like Fandou Béri , multiple strategies and differentiation in soil fertility investment can still be found.
- The Machakos District, in the Eastern Province of Kenya, has a population of about 100 people per km² (Nandwa *et al.*, 2000). The rainfall, which comes in two principal seasons is between 500-1500 mm, but about 85% of the region is classified as semi-arid to arid (Kassam *et al.*, 1991). Lowland soils are low in nitrogen, phosphorus and organic matter (Jaetzold and Schmidt, 1983), but according to Tiffen *et al.* (1994), there had been a long-term commitment by farmers to soil conservation, and farm outputs had doubled since the 1960s. Farmers grow sorghum, beans, pigeon peas, maize and fruit trees and they keep cattle, goats and poultry. Farmers had invested in organic manures (especially

through livestock integration for the fertilisation of subsistence crops), as at Fandou Béri. According to Onduru *et al.* (1999), the choice to invest in organic manures was dependent on access to labour, capital and transport, and the availability of good quality materials. Combinations of technologies (such as inorganic fertiliser for cash crops) only proved successful for farmers who had small plots of short-fallow, as consistent with other areas of Kenya (Swinkels *et al.* 1997). Such combinations are not cost-effective for farmers in Fandou Béri, constrained as they are by low labour availability and poor market for cash crops. However, as in Fandou Béri (see Chapter Six), there were significant differences in soil fertility practice between households, and De Jagger *et al.* (1999) raised concerns about the sustainability of soil use for some households that had negative nutrient balances in nitrogen, phosphorus and potassium.

9.2 Farming and soil fertility management at Fandou Béri

- This study found a local narrative representing the landscape as a 'lifescape'; an environment that is a product of a complex sequence of agricultural decisions and responses governed by the rains (section 5.1). The pattern of landscape ecology is the outcome of village history and livelihood response. The local narrative also revealed the environment to be characterised by dynamic patterns of microdiversity (Chapter Five). Farmers perceived the soil to have ephemeral qualities, where fertility declines and improves over time and space depending on the rainfall and human activities. Local people observed these qualities using indicators and proxies (e.g. vegetation cover, species and characteristics, crop yields and crop characteristics, and soil characteristics) (section 5.2). The local narrative leads to the study to conclude that there are dynamic transformations in natural capital in Fandou Béri rather than a degradation spiral. Although soil fertility is low and there are fields with serious erosion, farmers have used their IK to develop a more intensive farming system and upgrade the fodder system as they rebuild livestock numbers after droughts.

- Farmers' adaptive practice and exploitation of IK reinforces the local narrative (Chapter Five). Changes to practice through the rainy season are rarely the fault of the farmers' plan but their spontaneous reflection on the diversity of ecosystem and their changing household situation (Chapter Six and Seven). This means that farmers are continuously adjusting, fine-tuning and adapting in a process of innovation and experimentation. Flexibility is key.

- This study identified the determinants of land allocation in agriculture as the various aspects of household productive capacity (i.e. skills and knowledge, family labour, cash, manure, ability to enact entitlement, tenure arrangements) (Chapter Five and Six). These are tempered by unpredictable feedback (i.e. drought, social pressures, pest outbreak, loss of labour, conflict, or farmer mistake) (section 6.3.1). Fallow allocation was maintained for grazing fodder, although it was also perceived to provide soil fertility benefits while in rotation. Farmers believed that unnecessary fallow on the farm represented a constraint (section 6.2.2.4). The fallow rotation system in Fandou Béri appeared not to be so much a natural state of low population density agriculture but rather a strategy that was pursued as part of adjusting farm practices to the ecology and to changing household 'capital assets' (Chapter Five).

- Farmers in the study perceived the soil to be the most important part of their natural capital that they were able to influence. Poor quality soils were found to have the most intensive management because of their low productivity (section 6.2.4). This correlation suggests that the low organic matter is not necessarily a sign of degradation, especially since very few nutrients are exported from the village. The limited means of improving the soil meant farmers had to use targeted 'precision' agricultural practices to minimise nutrient losses, maximise nutrient recycling and exploit the natural biodiversity (section 5.3). Therefore, understanding local investment in soil fertility maintenance required an understanding of the intentions and reasons that people have for their activities. The study identified the determinants of soil investment as: the productive potential of land (i.e. rainfall, farm size and fragmentation, land-use history and bioproductivity, which includes soil moisture, soil type, erosion, texture, vegetation); the units of productive capacity (i.e. family labour, cash, skills and knowledge, manure, and ability to enact entitlements); livestock (i.e. herd composition, skills and knowledge, and the markets); commercial activities (i.e. level of income from petty trade, migrant work, and customary exchange); the size of the last season's grain harvest (i.e. biodiversity of stock and type of crops); and institutions (informal and formal) (Chapter Six).

- Farmers attached importance to livestock in the process of soil fertility investment (Chapters Five and Six). They argued that there is potential for further livestock integration in Fandou Béri without environmental damage. Although traditional exchange systems between the Fulani and the Djerma remain important, the study showed that smallstock ownership by Djerma has increased since the price rises on inorganic fertilisers in 1994, despite drought years (section 4.1 and 5.3.1). Djerma perceived livestock to be a cheap means of improving soil fertility, with grazing preferred because of the low labour requirement. In the long-term, labour-to-land ratios may improve as farm size decreases, leaving more labour available to divert to plant and collect fodder crops.

- Determinants for resource allocation and investment interact over various spatial and temporal scales (Chapter Six). For example, labour activities respond to temporal patterns of rainfall, while soil treatments respond to spatial patterns of productivity. These patterns produce differences in management over the farm, creating zones at household level but not at village level (section 6.2.4). The study found a positive relationship between returns to labour and land use intensity.

- Comparisons of IK and scientific mapping categories find some similarities (section 6.2.4.1). However, there are many differences in perceptions of soil fertility management between local science and agricultural science, illustrating a continuing dichotomy in many areas of environmental ideology (Chapters Two and Five). Agricultural science is abstract and transferable, while local science in Fandou Béri is grounded in people's perceptions of landscape, history and identity. It is also based on different sources of knowledge, which include 'intuitive preferences, admiration, predilection, faithfulness to tradition, and responsibility' (Van der Ploeg, 1991:212). Accepting this inclusive nature of local environmental knowledge, the existence of multiple realities, the relativated position of scientific knowledge, and the importance of farmers' knowledge in intervention design means a fundamental shift for most agricultural scientists.

- While there is evidence for intensified farming, shorter fallow-cycles, poor fertility and erosion within Fandou Béri, as in surrounding villages in the region, this study has shown the complexity of processes involved and the multiplicity of perspectives that can be focused on these issues (Chapters Four and Five). This study found farmers to be compensating for their low technology and lack of inorganic inputs by relying more on their management skills. The evidence from this study suggests that the continuing reduction in land availability in the Fandou Béri territory, due to population growth, will not necessarily lead to degradation, expansion into all marginal lands or decreased productivity. Instead some farmers practice more intense weeding, more frequent re-sowing, the use of more appropriate landraces, more attention to plant spacing, thinning, intercropping and sequencing, as well as fodder integration and especially the increased use of organic inputs and recycling (e.g. mulching of crop residues or manuring). The promotion of these practices by farmers and agricultural scientists are the result of different agendas; farmers have focused on maintaining productivity while agricultural scientists have focused on soil conservation. Most importantly, many households viewed farming as a subsistence operation, and therefore did not have a commercial interest in investing more time or money into soil fertility conservation.

9.3 Multiple paths of intensification – diversity in management

- There was diversity between households' farming practice and soil fertility management in Fandou Béri (Chapters Five and Six). It is important to recognise these multiple pathways in intensification models. Any theoretical model that envisages a single trajectory from shifting cultivation to intensification and mixed farming fails to capture the essence of rural change.

- This study identified three reasons for the diversity in Fandou Béri:
  - First, because of the different household situations. Each household had a different endowment of 'capital assets' to draw upon when making choices (section 5.5 and Chapter Six).
  - Second, because of the different way those households perceived their 'capital assets' (section 5.4.2). The way people perceived their 'capital assets' depended on their skills and knowledge, their ability to recognise opportunities and resolve constraints, and their ideas of identity. This influenced how individuals prioritised their 'capital assets' and the resulting 'capital' flows for resource investment.
  - Third, because access to endowments is influenced by an individual's capacity to enact entitlement, all the capital assets have social implications and call for value judgements and power resolution (section 6.3 and Chapter Seven). The individual household strategy remains a matter of choice and access, with the aim to retain flexibility and convertibility in assets. Therein lies the problem; access to resources is unequal and the influence of status, power and identity are linked to this (section 5.4.2 and Chapter Eight). Some people have better access and a greater capability to convert assets than have others. For example, fields on large but unfragmented farms were found to have a larger fallow area as a percentage of the field. Local animals came to graze the fallow, and thus transferred nutrients from other farms to the owners' field. These farmers were also able to corrall their own smallstock on the large plots of fallow without involving much labour or losing nutrients to neighbouring farms (Chapter Five). Furthermore, although a household may own several smallstock, whether or not they are able to transport the compound manure and night-soil to the field depends on the ownership of a donkey, or even a cart, and the labour to undertake the task. Farmers who owned a donkey but few smallstock were still able to transport gifts of manure, household waste or organic matter from the communal refuse heaps outside the village to their fields.

- This study identified patterns of differentiation in management strategies:
  - The strongest influences on differentiation in Fandou Béri were ethnicity (Djerma and Fulani – the Fulani had the most diverse incomes), wealth (livestock, especially smallstock) and access to family labour (household size and composition) (Chapter Six).
  - These influences produced the following pattern of differentiation for Djerma households:

    (a) Wealthy and/or large households (where family labour is most responsive to demand, providing flexibility in farm operations). These households were able to cultivate more fields (they had less fallow on their farms), to liquidate assets for cash readily (to use for paid labour, extra grain, manure contracts, businesses interests, livestock speculation) and had more smallstock for manure (sections 6.3.1 and 6.4).

    (b) Poor and/or small households. Social and human capital are most strategic in farm operations for these households (sections 6.3.1 and 6.4). Farmers rely on exploiting IK to compensate for limited inputs (Chapter Five).
  - Farm size proved to be a misleading indicator of differentiation. Small farms did not equate with poor households. Chapter Six showed that small farms had more intensive management and some farmers even had high numbers of smallstock. This contradicts assumptions made within the degradation discourse.

- The study found that a household's situation and its endowments, choices and capacity to respond was temporally dynamic (Chapter Five and section 6.3). The diversity of livelihood situation, knowledge and experience will continue to promote multiple routes of livelihood response, with varying rates of agricultural investment. Thus, different combinations of capitals are important at different times. These multiple pathways, constrained primarily by labour, inputs, quality land and quickly accessible cash, could lend themselves to suggestions of negative centrifugal forces, of economic polarisation and class differentiation (section 6.4). However, set within the wider context of processes of indigenisation, diversification, and the multi-spatial nature of households, the concept of 'rural' livelihoods takes on new meaning (Chapter Seven). Trends, shocks and seasonality (i.e. crop production, food and livestock prices, rainfall, health, employment opportunities) in contextual factors strongly define poor people's vulnerability in Fandou Béri (Chapters Six and Seven). They may be anticipated in many cases but are usually not in ordinary people's sphere of direct influence. Preparing for a decline in producer prices or a drought is often implicit in livelihood strategies; people build up their capitals to reduce their vulnerability. However, this may result in short or long-term costs, including the use of natural capital.

9.4 Farming within a rural livelihood

- Farming in Fandou Béri is a product of social context. A multisectoral analysis of households' wider livelihood structure was needed to understand farming choice, prioritisation and flow into and out of the farm. The influence of the local economy in the case studies helped in understanding farmers' rationales in farm management through their particular socio-cultural and economic histories (section 6.3 and Chapter Seven).

- This study found that households made continual substitutions between capitals, that there were different trade-offs for different households and some households were better able to make substitutions:
  - Substitutions took the form of cash and non-cash transactions (Chapter Seven). Households simultaneously engaged in both the cash economy and the customary exchange system. Investment into the farm sector came from income from NR products and non-NR activities. Non-cash based transactions were critical to farm investment, and did not appear in cash-flow analysis of household diversification (section 7.3). Furthermore, there were unaccounted transactions from the household to kin networks. These activities identified the need to understand the activities of all household members, not just those of the farming head, because individuals did not always act in their individual

interest (for example, feedback from the informal sector and animal husbandry into the farming component) (Chapter Five, section 6.3 and 7.1).

- Wealthy and/or large households interacted most in the cash-based economy. Women's activities were especially important (the larger household unit had two or three wives and extended family) for investing in future labour, market remittances, help to raise more smallstock, and to achieve better relationships with family support networks. Large households were able to diversify their income without damaging labour availability. Non-NR activities were primarily entered into as a form of additional business, rather than as a coping strategy. These households were able to invest in their sons' off-farm education, training and petty trading activities, and this provided return flows of cash (sections 6.3, 6.4 and Chapter Seven). These activities increased the household's balance of return substitution (to natural capital) and response to livelihood constraints (for example, liquidation of livestock assets for cash at times of difficulty, section 6.3). This gave more choices for substitution and resulted in short-term trade-offs. For example, natural capital (e.g. soil mining) was frequently converted into social (e.g. gifts) or financial capital (e.g. cash-crop sales), then converted into financial/natural capital (e.g. livestock) for natural capital investment (e.g. manure for soil fertility improvement) (section 7.3).
- Poor and/or small households relied mostly on non-cash systems of substitution for farm investment (sections 6.4 and 7.3). Social capital was the most common form of investment into the farm, while cash from non-NR activities (primarily as a part of a coping strategy) were used to buy household essentials. NR-based products were their primary source of cash for reinvestment in the farm, although profits were not always returned (natural capital substitution). These trade-offs created a vulnerability to drought, labour bottlenecks, and the possible liquidation of critical household assets.

• The study identified many contextual factors within the wider framework (e.g. governance, macro-economics, policy and the market, labour markets and employment opportunities, intervention) that have conspired to influence farming practice and the availability and value of different capitals (Chapter Seven). As a hinterland village, Fandou Béri was linked to urban markets, infrastructure, the informal sector, and their fluctuations. Thus a household's livelihood structure and its choices, capacity and response to resource allocation were linked to the wider framework (sections 6.3.1 and 7.1). Thus, factors beyond farming influence a household's vulnerability. As already concluded, households are differentially vulnerable to these changes. Some are well placed to take advantage of the opportunities offered by the wider system (Chapter Six and Seven).

- These dynamic livelihood systems are supported by a system of social organisation that relieves the constraints on resources that the agricultural system would otherwise face. For example, land is accessed in such a way as to allow the fallow system to exist at higher population densities (section 7.2), a system of co-operation has developed between the Djerma and Fulani groups based on capital substitution (section 7.3) and complex redistribution mechanisms exist for capital flows in Djerma society (Chapter Five, section 6.3). The study found that institutions mediated livelihood change and shaped the ways in which actors access, use and derive livelihoods from environmental resources and services at Fandou Béri. These institutions operated at different scales; formal institutions and processes (e.g. the international markets, controls on crops pricing and farm inputs, government agricultural advice, tenure laws, decentralisation, taxation, public services) and informal networks and institutions (e.g. religious support and family ties, associations, development of networks, ethnic interaction, customary exchange systems) were important to farm investment (sections 5.1 and 5.4, Chapters Six, Seven and Eight).

- The ability of households to enact complex substitutions between capitals and between different areas of their livelihood structure illustrated how difficult it is to label households or to create dichotomies between them (Chapter Six and Seven). The study highlighted how household situations can change (changing resource prioritisation and allocation). Households that have the greatest opportunities for farm investment because they have the most choices and diverse portfolio of substitutions are the least vulnerable, whilst households that have fewer opportunities for farm investment are the most vulnerable.

9.5 Sustainability at Fandou Béri

This study has shown that there is no need to 'teach' farmers in Fandou Béri about sustainability. Within a historical context, livelihood sustainability is a way of life for rural dwellers. The agricultural landscape is shaped by particular conjunctures of events which have precipitated changes in farming strategies, which themselves determine the pattern and path of crop-livestock integration. It is clear that actors at Fandou Béri have agency in this process, and therefore any understanding of the strategies of land use allocation, farm prioritisation and soil fertility investment must explore the trade-offs between different social actors. As Morton and Mathewman (1996:3) point out: 'the point at which it becomes worthwhile to invest labour in fodder cultivation, constructions for soil conservation, manure distribution and inorganic practice, will arrive at different times for different households'. Similarly, opportunities will be taken up unevenly by households. As section 9.4 has illustrated, it is difficult to identify a trajectory of change conclusively when there is evidence for multiple paths of intensification and interest in commercial farming. There is no one overall capital that needs to be sustained for 'sustainable' livelihoods to develop since capitals are interlinked at different scales and concepts of 'critical levels' of capitals are even more subjective. Instead, agricultural sustainability in Fandou Béri is dependent on households being able to resolve their weaknesses (areas for future research) and build on their strengths (as indicated by sustainable livelihood outcomes – see sections 3.3 and 2.2.2) as the following points indicate:

Weaknesses that need to be resolved to build sustainability:

- *Policy disincentives*

  Ultimately there are limits to bottom-up solutions. There is need for some state guidance, currently lacking, which would still allow rural dwellers to retain some autonomy. National policy currently does not favour rural sector investment. Nigerien smallholders have endured cuts in subsidies, rural extension support, and formal credit (because it could not be repaid in drought years). Ultimately policy should provide better incentives to invest different forms of capital (e.g. labour, cash, livestock) in farm productivity. Targeted agricultural support could include appropriate crop pricing and open markets, micro-financing for credit systems and investment in infrastructure. Fertilisers are also too expensive to be option at current prices and ways of bringing their prices down should be considered. Boosting the local economy would reduce the portion of the labour force leaving the region to search for cash, although the effect of the growing informal sector or the impact of Niamey on its hinterland region cannot be underestimated. With unreliable rainfall, many people are bound to remain in the informal sector and livelihood diversification may continue to develop, especially if national markets change.

- *High levels of illiteracy*

  There is poor access to education for both children and adults in Fandou Béri. Low levels of literacy and numeracy have contributed to poor communication and exchange of new ideas, business failures and difficulty in entering better paid employment in the informal sector. Since the wealthier households have better access to education or training, the power structure is reinforced by poor education. There is a danger that the decentralisation process could also contribute to this inequality when those higher in the power structure become involved in local government.

- *Shortage of manure*

  While livestock ownership has increased, not all farmers have the capacity to increase organic inputs. For the wealthy manure shortages result from transport constraints, while the poor have too few animals. Given many farmers' labour constraints, improved transport would permit better cycling of the nutrients already within the village, reduce labour demands, and aid the integration of smallstock already owned. Flexible micro-scale credit schemes would help poorer households to purchase smallstock and reduce inequalities in access to manure inputs. Improved co-operation between Djerma and Fulani and fodder integration would also raise nutrient inputs.

- *Continuing subdivision of farms*

  A combination of land consolidation, inheritance reform, more effective land markets, and labour-absorbing intensification of production may offer a solution, and in the long-term new opportunities outside of agriculture.

- *Pricing at markets*

  Improved prices for NR-products at market would act as an incentive to farmers. Cash crops are currently not seen as a secure livelihood income. Development of infrastructure, transport and local markets for NR-products would help the local economy. Free trade has not resolved the problem of unequal access.

- *Proneness to drought*

  Poor and/or small households are particular vulnerable to drought-triggered poverty. This is exacerbated by high grain prices, unequal distribution of aid, a lack of access to credit, high risks to livestock health and human health (reducing family labour availability). At these times, they become dependent on relief from family elsewhere and charitable systems in Djerma society. The vulnerability of these households would be reduced if there were better access to healthcare, integrated nutrient management (including the limited use of inorganic fertilisers), better links between off-farm family members and the household, and flexible and multiple sources of credit and support, are targeted to those with little capital of any kind.

- *Weak cash-economy*

  There is a danger in focusing too much on social capital and non-cash transactions to solve household constraints because this could reinforce traditional structures of power and conflict. There is a need to enhance people's rights and capacity to act, which would provide better opportunities for cash-based access for households.

- *Soil loss*

  A fuller understanding of nutrient patterns and erosion across farms and between households in Fandou Béri would provide a better picture of investment allocation. It is currently difficult to distinguish between degradation caused by erosion, nutrient decline, management or rainfall decline.

- *Minor disputes over land*

  There is a history of land conflicts in Fandou Béri. The most recent disputes can be linked to insecurity promoted by tenure reforms in the mid-1990s. Application of these laws needs to promote rights-based access and acknowledge the flexibility of customary systems. Intervention might be better to look at resolving conflict, integrating farmers and herders, and dealing with power and communication. Replacing multiple grazing resources, in space and time, by a dependency on crop residues and weeds reduces grazing flexibility. There are many unresolved questions of how best to promote investment in fodder management and integrate livestock, when fallow areas are decreasing, fodder demands are increasing and communal rangelands are being privatised. Serious conflicts over access resources have occurred recently in other parts of south-west Niger.

- *Dependency*

  Activities by NGOs, researchers and intervention projects have built up some farmers' expectation of receiving aid and cheap fertiliser, but reduced their interest in serious long-term investment. This illustrates why it is important to have participation in the process of environmental problem-framing in the first place. Farmers are interested in adaptation and flexibility whereas project planners pursue sustainability and permanent solutions. Farmers were in the habit of keeping the worst case scenario uppermost in their minds, viewing sustainable solutions (especially those in scientists' perceptions) with cynicism. It is important to provide participatory private ventures or appropriate technologies with short-term benefits, in order to change farmers' perceptions of 'development projects' (e.g. micro-finance systems which feedback to farm investment, or participation in experimentation). Besides participatory projects, temporary assistance may be necessary at difficult times for some households, although identifying these 'critical moments' (associated with life-cycle transitions, the agrarian season and rainfall) will remain complex.

- *Labour constraints*

  Farmers use more family labour than hired labour. This can be interpreted as a constraint. Households do not use less family labour in bottleneck periods and there is a weak labour market. The hired wage-rate is not high enough to induce households to decrease the input of labour on their own farms in order to work for wages elsewhere. Only the poorest households do this and there is a cultural stigma attached to working for cash (although not for non-cash assistance). Family labour bottlenecks can be increased if sons do not return from seasonal off-farm work promptly at the beginning of the rainy season. Although most do return during the rainy season, tied to the fallback of subsistence agriculture and the autonomy this offers. Farmers could increase their returns significantly if they had more labour in the rainy season. More sustainable intensification could be achieved if these seasonal labour bottlenecks were alleviated, giving more flexibility, and by providing better access to healthcare (sickness and tiredness reduces labour availability). However, the differentiation and multidimensionality of livelihoods means that it is difficult for donor interventions to make changes here. The examples indicate that poorer households will preferentially adopt labour saving techniques, rather than intensive tasks, such as digging trenches, using irrigation or organic manuring. These poor, labour-deficient households may be the most vulnerable to productivity decline with increases in land use intensity, subdivision and fragmentation and should be the first target of NGO support. Livelihood assistance to villagers would attend to short-term labour time management, and longer-term capital investment and planning. Time management is not just about dovetailing daily or seasonal activities. A sense of direction is vital for optimising labour, providing the focus that the SLF approach largely circumvents (focusing instead on rural dwellers long-term agrarian prospects).

Strengths to build sustainability:

- *Skills at coping and managing diversification*

  The lack of state support has meant that people have developed alternative strategies for supporting their family and investing in farming. The rural household does not only concern itself with farming; there is also a high non-NR income. This results from rural-urban circular migration, education, the development of entrepreneurial skills, and the mixing of the local cash economy with systems of customary exchange enhance capabilities. For 'the new rurality', diversification into the growing informal sector is an attractive strategy and is more than a short-term 'coping strategy'. Whether households view the farm as a means to subsistence, or a more strategic part of their livelihood portfolio, depends on rapidly changing national economic policies, market incentives, access to credit and the rainfall variability. Rural dwellers are skilled at responding to these changes by capital substitution.

- *Hinterland village*

  The proximity to Niamey offers a potential incentive to farming investment because of growing crops, livestock and other product markets in the urban area as well as the easy access to infrastructure and transport.

- *Farming experience and IK*

  Farmers have been more successful in managing a difficult environment than they have been given credit for. For example, using their experience, skills and local knowledge they have achieved fodder integration with decreasing rangeland and fallow and without major conflict with herders. Corralling and precision targeting of organic inputs, based on IK, is an efficient method of improving (internally sourced) inputs to the nutrient system with low labour. In landrace management, farmers are skilled in the retention and development of biodiversity and local genetic modification. For these reasons, it is essential that the development and assessment of new technologies and practices is participatory. Previous intervention projects in the village have promoted the image of efficient and easy intensive farming with external inputs that are currently beyond farmers' means. However, participatory science can provide farmers with advice on the most efficient applications with varying rainfall and resources. By creating opportunities for choice, diversity, innovation and integrated types of farm management, the capacity and incentive for farmers to invest in soil fertility will increase. For example, smallstock credit schemes and transport co-operatives can boost the local economy and reduce inequality in access to resources. Soil conservation interventions would need to enrol IK and demonstrate benefits in terms of productivity.

- *Social institutions*

  Forms of local co-operation, customary systems and task specialisation (e.g. inter-ethnic links between herders and farmers, patron-client and family ties, local systems of tenure, customary exchange and conflict resolution, associations) should be built upon to provide more secure, diverse and flexible support systems (e.g. flexible credit schemes, better linkages between off-farm family, improved entitlements and access to resources, decentralised power over local resources and markets).

- *Natural resources*

  There are diverse sources of natural capitals, with natural diversity and spatial variability. Farmers are still able to produce crops from these resources. It will be important to farmers to continue to improve ways of using these resources by working with natural diversity.

- *The role of women in the household*

  Although farm work remains predominantly the 'men's responsibility', women play an important role in the household economy with their activities in smallstock rearing, market sales, non-cash exchange, as a source of additional labour, and in developing networks of family support. Their success influences the household capacity to invest in the farm and they will have increasingly important role if they continue to control smallstock ownership. Developing women's capacity to enact entitlements and secure access to resources will ensure household stability.

- *Multiple strategies*

  Social differentiation, ecological variability and the dynamic relationship between people and environment needs to be recognised. The history of these relations is important in shaping current and future management possibilities. Furthermore, particular trajectories of landscape change will bring a different distribution of costs and benefits to different groups of people. These issues make it difficult to identify an environmental ideal to which 'community based sustainable development' should aspire. Multiple strategies instead shift the focus to different groups of actors, who may give priority to different environmental resources or services. Landscape change, soil fertility and farm investment and resource conservation are fundamentally social and political processes, involving negotiations and conflicts between actors with different priorities who are differently positioned in relation to power. Any strategy designed to enhance capabilities would need to consider gender, class, ethnicity, political status and other forms of power. Development initiatives should promote integrated options for participatory experiment and the indigenisation of appropriate technology (not just passive transfer) to maintain choice depending on household situation.

Appendix 1 Quantitative data summary from SERIDA database and 1998 fieldwork

ID	Natural				Social					Physical	
	AvProd/kg	1997Mharv	FallowAge	RFertility	LoanOut	LoanIn	ManureEx	Off-farmW	PettyTrade	Area/ha	Dist/km
F1A	366	196	7	2	1	0	1	2	1	4.1	0.9
F1B	388	208	0	3	1	0	0	2	1	5.2	2.4
F1C	112	60	0	5	1	0	0	2	1	1.4	2.3
F2A	244	153	0	2	0	0	1	0	0	3.6	0.1
F2B	18	12	0	5	0	0	0	0	0	0.3	0.2
F2C	54	34	0	2	0	0	0	0	0	0.8	0.1
F2D	16	10	0	1	0	0	0	0	0	0.4	1
F3A	463	175	2	1	1	0	0	4	1	1.8	0.3
F3B	809	476	1	2	1	0	0	4	1	4.9	2.2
F4A	291	189	3	1	0	2	0	2	1	3.5	2
F4B	307	200	0	3	0	2	0	2	1	4.9	4
F4C	200	130	0	2	0	2	0	2	1	2.5	1.1
F5A	553	84	3	1	0	0	0	2	1	1.7	1
F5B	800	220	0	3	0	0	0	2	1	4.6	3.2
F5C	263	40	4	2	0	0	0	2	1	1.1	3.5
F6A	331	469	0	4	1	0	0	1	0	6.9	1.2
F6B	50	61	0	1	1	0	0	1	0	0.9	2.6
F6C	95	80	0	4	1	0	0	1	0	1.2	0.7
F6D	200	130	0	2	1	0	0	1	0	1.9	0.1
F7A	1350	168	3	1	0	1	1	1	0	1.5	1.5
F7B	520	120	0	3	0	1	1	1	0	1.3	3
F8A	955	413	3	2	0	0	1	0	1	3.7	1.7
F8B	600	500	2	1	0	0	0	0	1	5	1.7
F8C	205	122	1	2	0	0	0	0	1	1.1	0.5
F9A	388	301	2	2	0	0	0	0	0	5.1	1.8
F9B	311	108	4	2	0	0	1	0	0	1.8	0.5
F9C	112	72	0	3	0	0	0	0	0	1.2	2.5
F10A	800	126	3	1	0	1	0	2	1	1.2	0.5
F10B	50	94	4	5	0	1	0	2	1	0.9	2.9
F10C	900	300	3	3	0	1	0	2	1	3.9	12
F11A	360	336	2	2	1	0	0	1	0	3.5	0.9
F11B	403	192	3	5	1	0	0	1	0	2	4
F11C	60	18	0	2	1	0	0	1	0	0.2	1
F12A	405	77	0	1	0	0	0	2	0	1	0.5
F12B	680	360	0	3	0	0	0	2	0	6.2	4
F12C	160	121	3	2	0	0	0	2	0	2.1	2.3
F13A	705	392	3	3	0	1	0	1	0	2.6	0.4
F13B	182	285	0	5	0	1	0	1	0	1.9	0.5
F13C	200	165	0	5	0	1	0	1	0	1.1	1.1
F14A	445	546	2	3	0	1	1	1	0	6.4	0.1
F15A	266	448	0	4	0	2	1	0	0	3.6	0.1
F16A	461	966	1	2	0	1	1	1	0	6.6	0.1
F17A	249	288	0	3	0	0	1	0	0	1.5	3.5
F17B	210	400	2	1	0	0	0	0	0	3	0.7
F17C	850	600	5	3	0	0	0	0	0	6.4	2.6
F18A	549	220	2	2	1	0	1	1	0	1.4	0.4
F18B	974	470	0	4	1	0	0	1	0	3	1
F18C	60	78	0	3	1	0	0	1	0	0.5	0.5
F19A	320	150	0	3	2	0	1	0	0	1.1	2.6
F19B	400	230	1	1	2	0	0	0	0	3	3.9
F19C	1260	800	4	2	2	0	0	0	0	1	2.8
F19D	50	40	0	2	2	0	0	0	0	0.3	3.9
F20A	260	291	2	2	0	4	1	0	0	4.1	3
F20B	494	134	3	3	0	4	0	0	0	1.9	0.5
F20C	161	90	0	1	0	4	0	0	0	1.9	1.6
F20D	922	772	0	2	0	4	0	0	0	13.2	4.2
F20E	50	15	0	2	0	4	0	0	0	0.2	0.6
F20F	50	20	0	2	0	4	0	0	0	0.3	0.3

Appendix 1 Quantitative data summary from SERIDA database and 1998 fieldwork

Economic										
TFieldsCul	CultA(ha)9	Fallow(ha)	Bush plots	PaidLab	FOwned	Tanimals	hhCattle	hhSmallRu	hhDonkeys	%Manured
3	2.7	1.3	2	0	6	3	1	2	0	0
3	5.2	0	2	0	6	3	1	2	0	30
3	1.4	0	2	0	6	3	1	2	0	0
4	3.6	0	0	5	4	60	22	33	5	60
4	0.3	0	0	5	4	60	22	33	5	0
4	0.8	0	0	5	4	60	22	33	5	0
4	0.4	0	0	5	4	60	22	33	5	0
2	1.2	0.6	1	0	4	12	4	7	1	40
2	4.4	0.5	1	0	4	12	4	7	1	0
2	2.8	0.7	1	0	1	6	2	4	0	0
2	4.9	0	1	0	1	6	2	4	0	0
2	2.4	0.13	1	0	1	6	2	4	0	0
3	0.3	1.36	0	0	3	5	0	5	0	40
3	4.6	0	0	0	3	5	0	5	0	0
3	0.6	0.44	0	0	3	5	0	5	0	0
4	6.9	0	1	0	6	8	4	2	2	0
4	0.9	0	1	0	6	8	4	2	2	0
4	1.2	0	1	0	6	8	4	2	2	0
4	1.9	0	1	0	6	8	4	2	2	0
2	1.2	0.3	1	2	2	7	1	6	0	0
2	1.3	0	1	2	2	7	1	6	0	0
3	2.5	1.2	0	3	3	9	1	5	3	0
3	3.3	1.7	0	3	3	9	1	5	3	0
3	0.7	0.4	0	3	3	9	1	5	3	30
2	3.4	1.7	1	0	3	8	2	6	0	60
2	1.2	0.6	1	0	3	8	2	6	0	40
2	1.2	0	1	0	3	8	2	6	0	0
4	1	0.2	0	0	3	30	17	13	0	40
4	0.8	0.1	0	0	3	30	17	13	0	0
4	2.6	1.3	0	0	3	30	17	13	0	0
2	2.3	1.2	1	0	4	9	3	6	0	0
2	1.8	0.2	1	0	4	9	3	6	0	0
2	0.2	0	1	0	4	9	3	6	0	0
3	1	0	0	0	3	24	15	8	1	50
3	6.2	0	0	0	3	24	15	8	1	0
3	1.4	0.7	0	0	3	24	15	8	1	0
4	1.7	0.9	0	0	3	10	5	5	0	0
4	1.9	0	0	0	3	10	5	5	0	30
4	1.1	0	0	0	3	10	5	5	0	0
1	4.8	1.6	0	4	0	73	24	41	1	80
1	3.6	0	1	0	0	116	20	17	2	80
1	5.9	0.7	0	3	0	65	27	14	6	80
3	1.5	0	1	7	4	25	6	16	3	0
3	1	2	1	7	4	25	6	16	3	30
3	4.3	2.1	1	7	4	25	6	16	3	0
3	1.1	0.3	4	6	10	17	5	12	0	30
5	3	0	4	6	10	17	5	12	0	40
5	0.5	0	4	6	10	17	5	12	0	30
4	1.1	0	2	0	6	106	32	70	4	0
4	2.7	0.3	2	0	6	106	32	70	4	0
4	0.7	0.3	2	0	6	106	32	70	4	20
4	0.3	0	2	0	6	106	32	70	4	0
6	1.6	2.5	0	4	2	15	5	10	0	0
6	1.3	0.6	0	4	2	15	5	10	0	0
6	1.9	0	0	4	2	15	5	10	0	50
6	13.2	0	0	4	2	15	5	10	0	0
6	0.2	0	0	4	2	15	5	10	0	0
6	0.3	0	0	4	2	15	5	10	0	0

Appendix 1 Quantitative data summary from SERIDA database and 1998 fieldwork

Human										
Thhincome	Thhexpens	HhMNeeds	Thhsize	Fhhsize	Mhhsize	FamLabW	%Burning	%Mulch	%Fallow	Mvariety
179425	188650	300	12	3	5	5	30	60	30	100
179425	188650	300	12	3	5	5	0	60	0	100
179425	188650	300	12	3	5	5	0	30	0	100
542125	507450	400	8	2	2	2	0	80	0	100
542125	507450	400	8	2	2	2	0	40	0	100
542125	507450	400	8	2	2	2	0	80	0	100
542125	507450	400	8	2	2	2	0	80	0	100
250825	820100	360	27	8	5	8	0	50	33	120
250825	820100	360	27	8	5	8	0	60	10	100
208300	351800	300	8	2	4	5	40	80	20	140
208300	351800	300	8	2	4	5	0	80	0	120
208300	351800	300	8	2	4	5	0	50	5	120
119225	169000	300	9	3	6	7	20	20	80	110
119225	169000	300	9	3	6	7	0	80	0	110
119225	169000	300	9	3	6	7	0	10	40	100
375875	246700	250	8	4	4	6	0	30	0	100
375875	246700	250	8	4	4	6	0	50	0	100
375875	246700	250	8	4	4	6	0	20	0	110
375875	246700	250	8	4	4	6	0	50	0	100
137475	110900	200	8	5	3	4	0	60	40	100
137475	110900	200	8	5	3	4	0	80	0	100
215925	227350	200	7	4	3	3	0	50	33	120
215925	227350	200	7	4	3	3	0	50	33	120
215925	227350	200	7	4	3	3	0	50	33	120
264100	264100	330	9	4	4	4	0	50	33	100
264100	264100	330	9	4	4	4	0	50	33	100
264100	264100	330	9	4	4	4	0	80	0	120
262025	320575	250	16	5	6	6	0	50	20	120
262025	320575	250	16	5	6	6	0	10	10	100
262025	320575	250	16	5	6	6	0	0	10	120
209800	224885	360	10	4	4	5	0	50	33	100
209800	224885	360	10	4	4	5	0	20	10	100
209800	224885	360	10	4	4	5	0	60	0	100
N/A	N/A	150	8	5	3	4	0	60	0	120
N/A	N/A	150	8	5	3	4	0	80	0	100
N/A	N/A	150	8	5	3	4	0	60	33	120
196050	200750	200	3	1	2	2	30	60	33	110
196050	200750	200	3	1	2	2	0	40	0	110
196050	200750	200	3	1	2	2	20	50	0	110
224125	316600	300	5	1	3	3	20	50	20	100
206925	136600	300	6	1	2	3	0	50	0	100
414825	366000	450	4	1	3	4	10	60	10	120
N/A	N/A	300	17	11	4	5	60	60	0	110
N/A	N/A	300	17	11	4	5	0	50	33	100
N/A	N/A	300	17	11	4	5	20	70	33	110
N/A	N/A	300	10	3	5	3	20	50	20	120
N/A	N/A	300	10	3	5	3	80	60	0	120
N/A	N/A	300	10	3	5	3	0	60	0	120
N/A	N/A	300	14	10	4	5	0	60	0	110
N/A	N/A	300	14	10	4	5	0	70	10	100
N/A	N/A	300	14	10	4	5	0	60	33	110
N/A	N/A	300	14	10	4	5	0	70	0	110
N/A	N/A	500	15	10	5	6	0	20	60	110
N/A	N/A	500	15	10	5	6	0	60	33	100
N/A	N/A	500	15	10	5	6	0	50	0	110
N/A	N/A	500	15	10	5	6	0	40	0	100
N/A	N/A	500	15	10	5	6	0	20	0	100
N/A	N/A	500	15	10	5	6	0	50	0	100

FICHE D'ENQUETE PRELIMINAIRE

No.		Date	

Nom du chef de l'exploitation	
SERIDA code	

Ethnie		**Origine**		
Age	0-20	20-40	40-60	60+
Lien avec chef				
Activités				

Les membres de la famille	F/M	Age	Exode?	Activités (principale/secondaire)
1. 2. 3. 4. 5. 6. 7. 8.				

Nombre de champs	**1**	**2**	**3**	**4**	**5**	**6***
SERIDA field?						
Etes-vous propriétaire du champ? O/N sinon: E = emprunt? A = achat? avec qui?						
Situation des champs: Près de village Système bas-fond Système jupe sableuse Système plateau						
Caractéristiques						
Sol: Sol sableux (tassi) Sol argileux (botogo) gangani korobanda Autre appellation locale du sol?						
La qualité? 1-5 (le meilleur – le pire)						

Sous culture = C En jachere = J						
Jachère: Age % secteur Durée de la jachère précedente? Temps en rotation?						
Culture: Année de la première mise en culture? Année de culture après jachère? % secteur Temps sous culture?						
Culture(s) practiquée(s) 1998 (Récolte - bottes) Mil = M Niébé = N Sorgo = So Oseille = O Arachide = A autres (coût)						
Culture(s) practiquée(s) 1997 (Récolte - bottes) Mil = M Niébé = N Sorgo = So Oseille = O Arachide = A autres						
Faites-vous de la fumure organique? O/N Type: parcage = P transport de fumier = T Autre? (le secteur? quand? provenance?)						
Utilisez-vous de l'engrais? (couleur, coût)						
Faites-vous des tiege?						

******Suite*

FICHE D'ENQUETE ITINERAIRE TECHNIQUE

No.		Date	

Nom du chef de l'exploitation	
SERIDA code	

date	no. champ	operation	Cause?	la temps? (cultivateur)	la temps? (la main d'oeuvre/ no.? cause? Paiement?)	sector	semis – la densité? variétés?	Outil

(SUITE) CROQUIS DU CHAMP

Indiquez (1-5 : zone intensif- sans): parcage, fumure organique, engrais, sarclage, no. arbustes, grands arbres, chemin, sol, zone à temites, direction de la pente, echelle (nombre de pas), semis, culture associée...

FICHE DE LA PARCELLE (10 X 10m)

Indiquez: culture associée (nombre poquets - mil, niebe...), no. arbustes, les caracteristiques...

FICHE D'ENQUETE RESSOURCES

No. | **Date**

Nom du chef de l'exploitation

Date	Bétail vendu	Bétail acheté	Echange contre l'argent	Ressources naturelle vendu	cadeaux	Autre activites commercialle	Exode	No. champ
Créancier? Débiteur ? Avec qui?								

Avez-vous du bétail? (comparez la base de données SERIDA) (nombre?) Bovins | Vaches | Moutons | Chevres | Asins | Equins | Autres Prendre soin du bétail?	
Si parcage, provenance: Principalement – petits ruminants/boeufs/égale Préférence? Païtre? Fulani? (les conditions du contrat) Pour combien de temps? Secteur? Lein/relations? Transport?	
La connaissance du culture associée: Mil = M, Niébé = N, Sorgo = So, Oseille = O, Arachide = A, autres Densité Coût 1. Culture principale 2. Culture secondaire 3. 4. 5. Préférence? Raison? Changer (sol/champ)? à vendre/provision? Rotation? L'insectes/mauvaise herbes…?	
La pluie: La connaissance/indicateurs - semis à sec La connaissance/indicateurs - semis humide Activités? Quelle culture (ordre?) La pluie critique – combien du jours?	

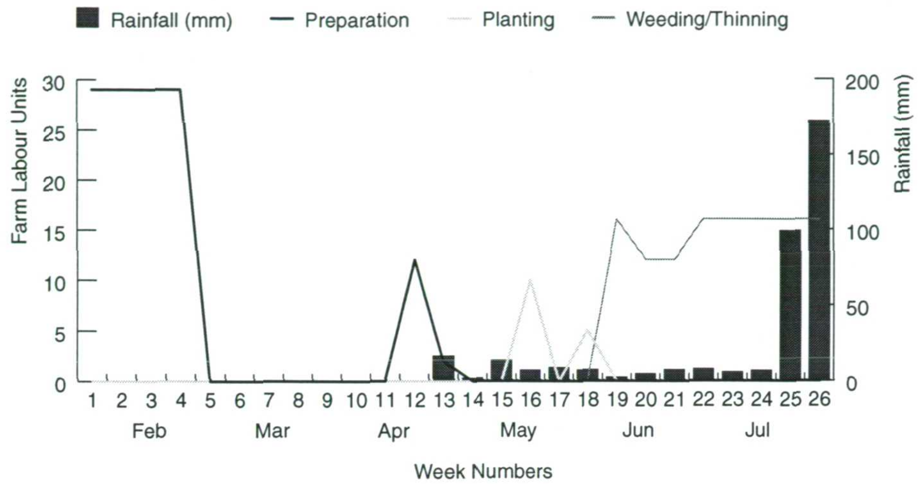
La connaissance du sol: Centre du travail? Si Oui, où/pourquoi? Une secteur en jachère, pourquoi? Indicateurs? Avez-vous vu un changement du sol (par champ/terroir)	
La priorité du travail? Où? Pourquoi? Employez-vous de la main d'oeuvre? Si oui, combien? Fournissez-vous de la main d'oeuvre? Si oui, pourquoi?	
Avez-vous contesté une parcelle/jachère/ligne de démarcation? Pourquoi? Résolution?	
Constraintes? Le plus important?	

Tracer le critère pour la jachère/mise en culture - le succès/l'échec

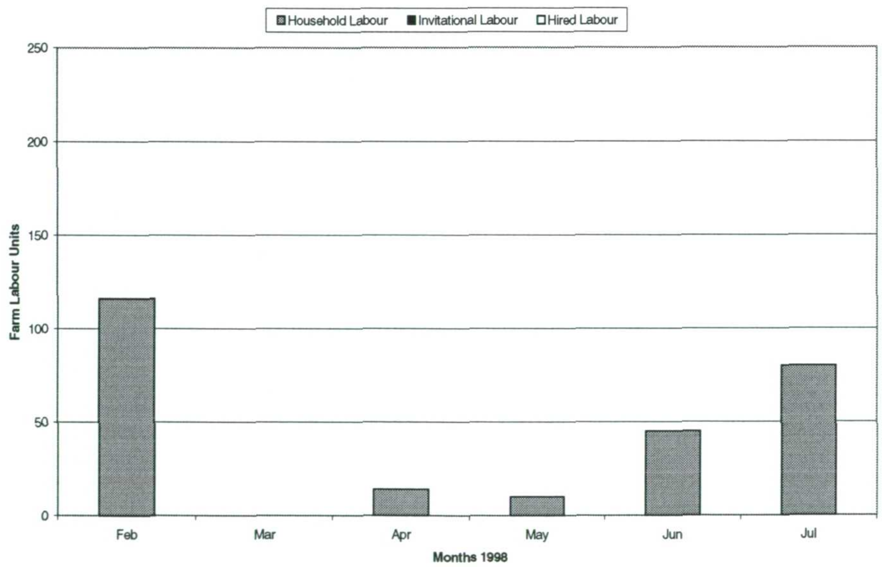
Appendix 3 (a) Household farm labour and rainfall in 1998 and (b) the composition of household, invitational and hired labour (source: own data 1998)

Kadri Yaye

(a)



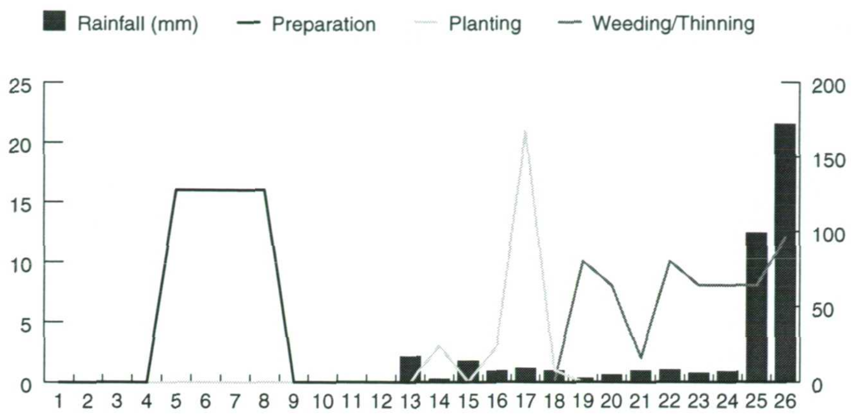
(b)



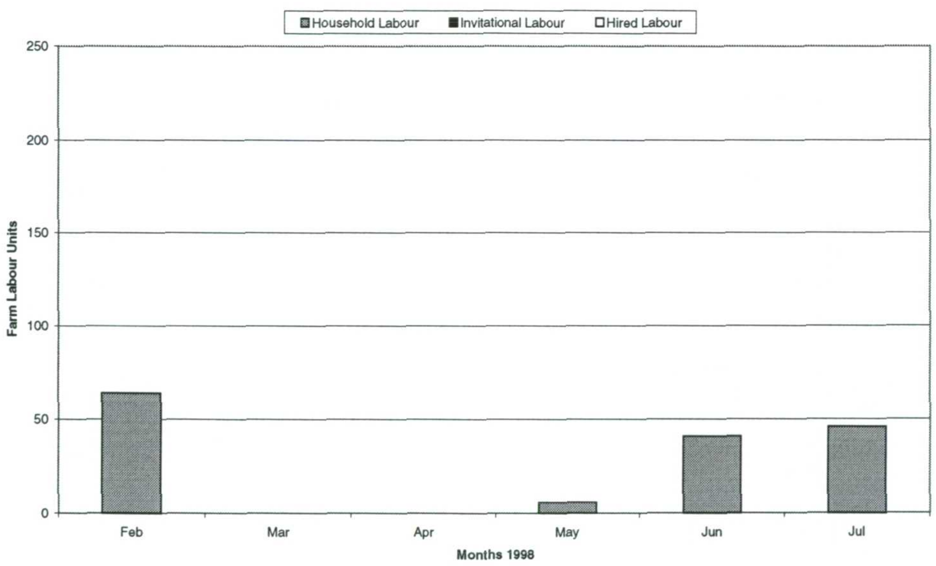
Note: The dry seeding activity this farmer practised before the first large rainfall event

2 Oumarou Hassane

(a)



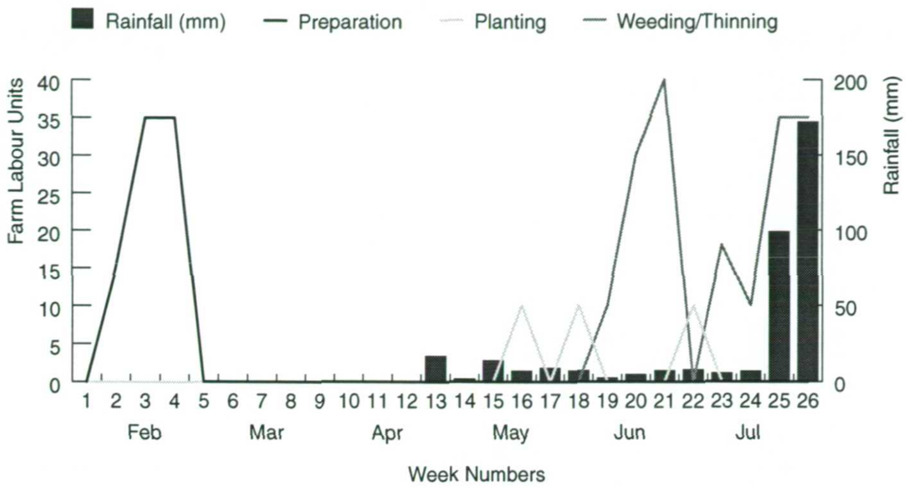
(b)



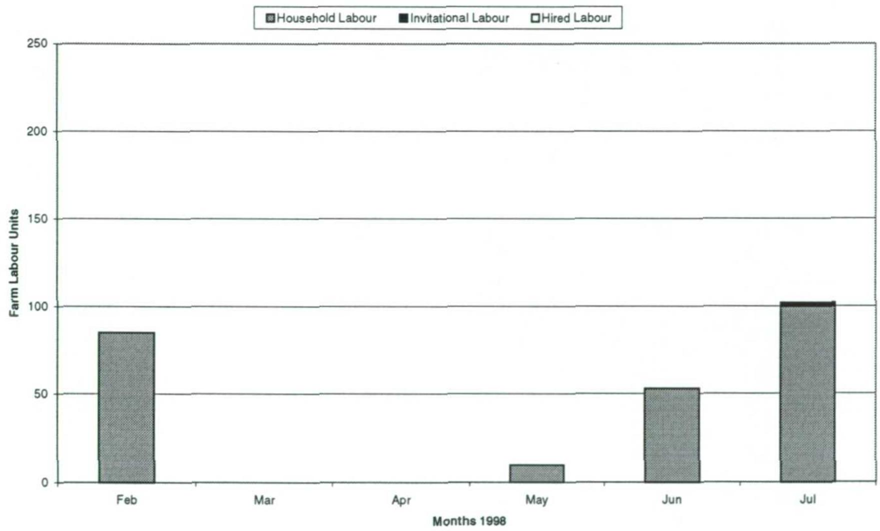
Note: This farmer waited until the second large rainfall event before deploying labour to the fields to plant.

3 Hassane Malam

(a)



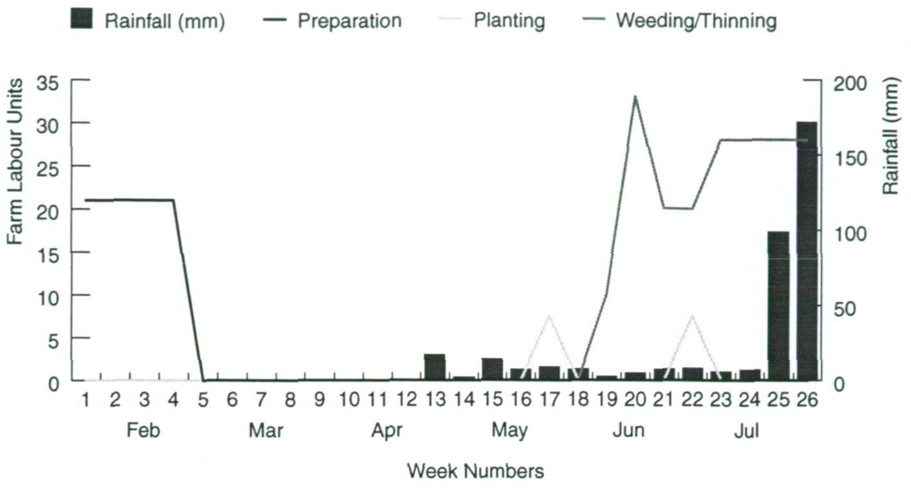
(b)



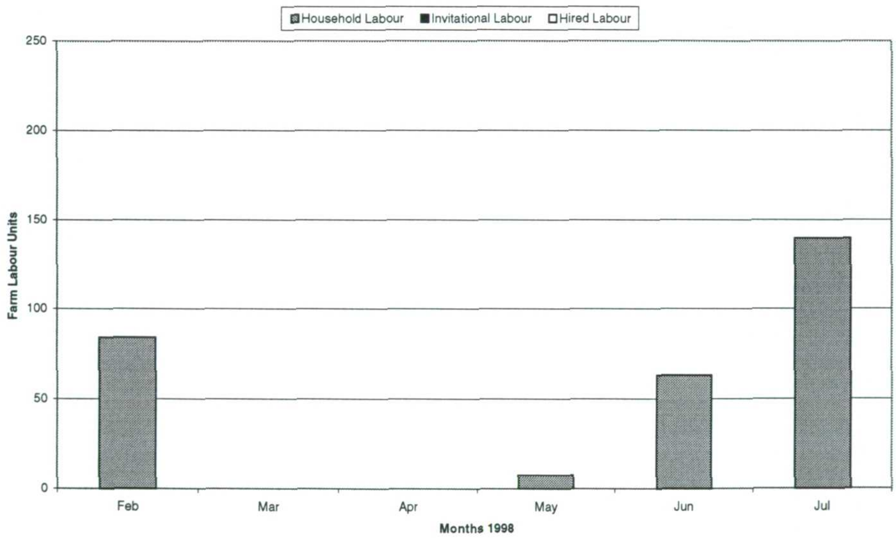
Note: This farmer had a high labour response, but waited for the second rain before seeding. He had a small percentage of invitational labour to help with weeding.

4 Yssaka Souley

(a)



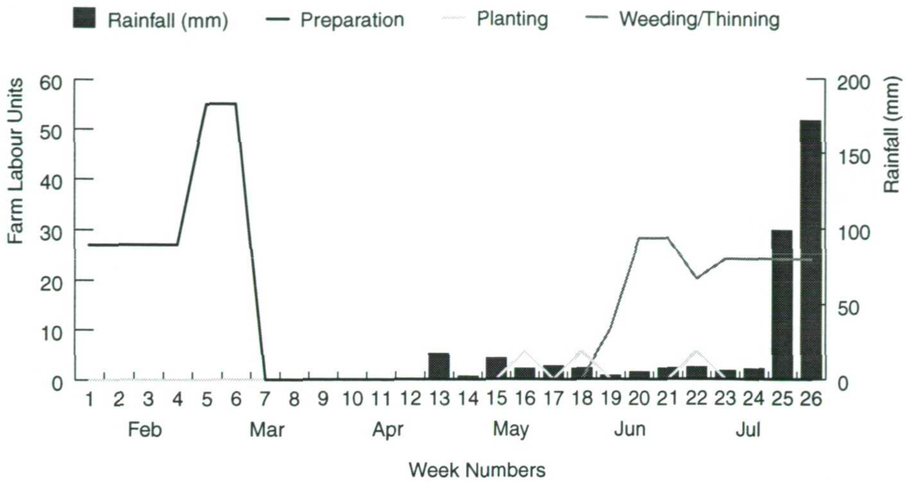
(b)



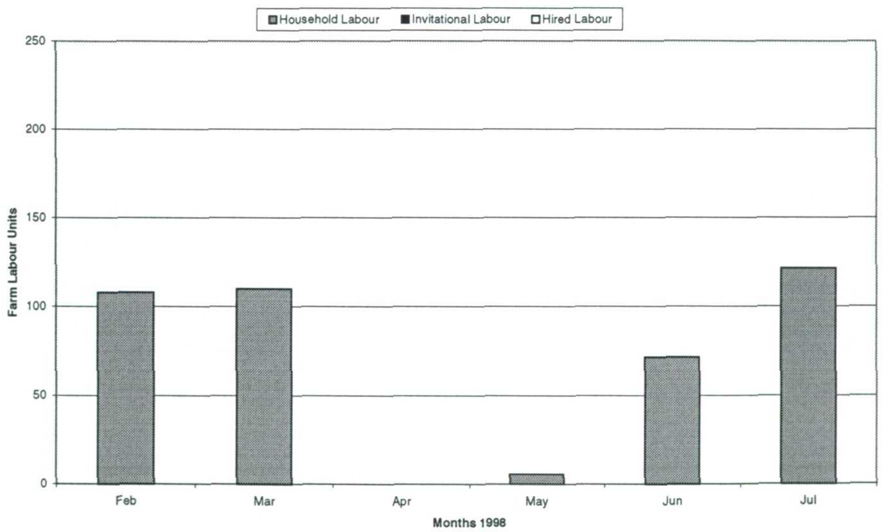
Note: This farmer had a late planting response to the first rainfall event.

6 Garba Abdou

(a)



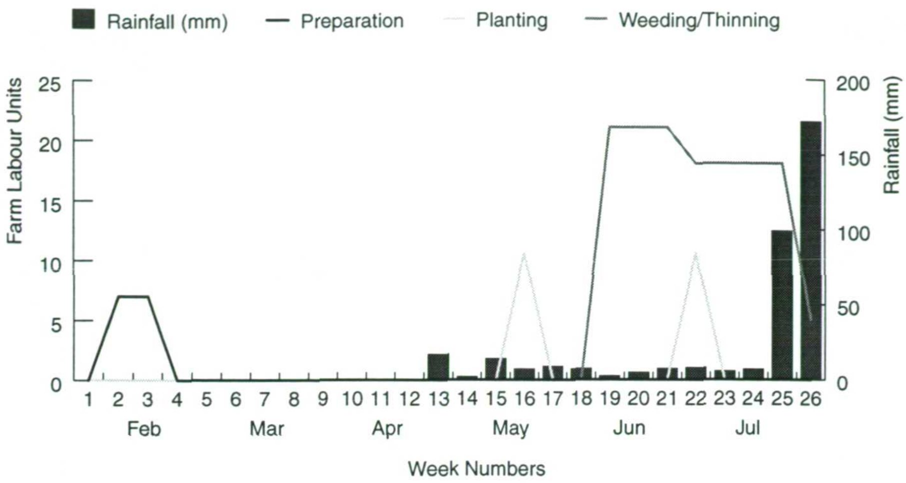
(b)



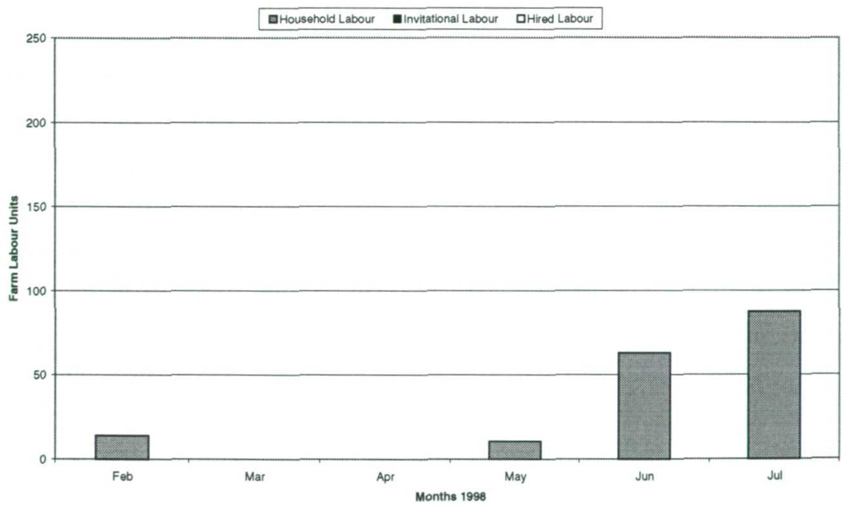
Note: This farmer invested high labour in preparing new field area but was unable to match the same planting and weeding labour demand (although the labour used is similar to other households).

9 Mounkali Djibo

(a)



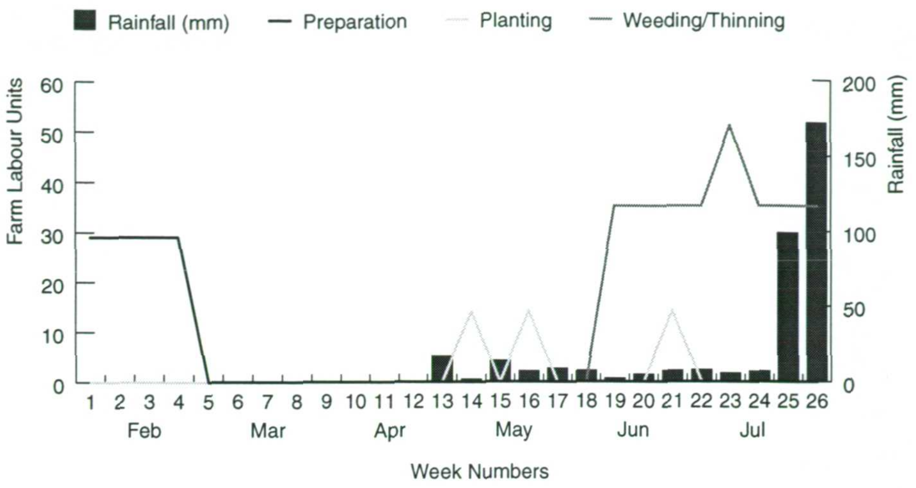
(b)



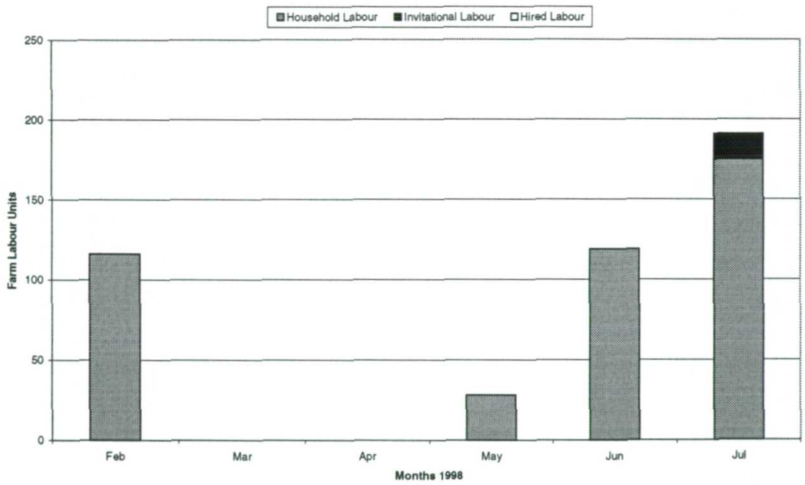
Note: The relatively low labour investment in field preparation.

10 Ide Aboullaye

(a)



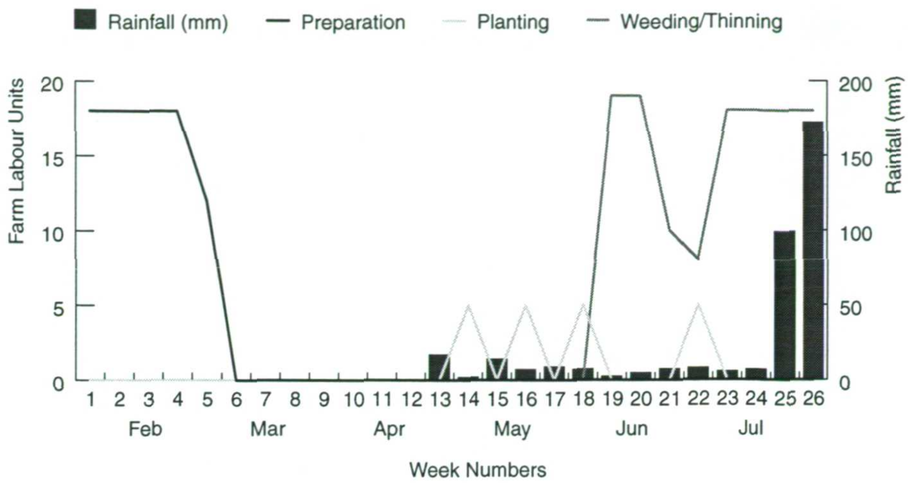
(b)



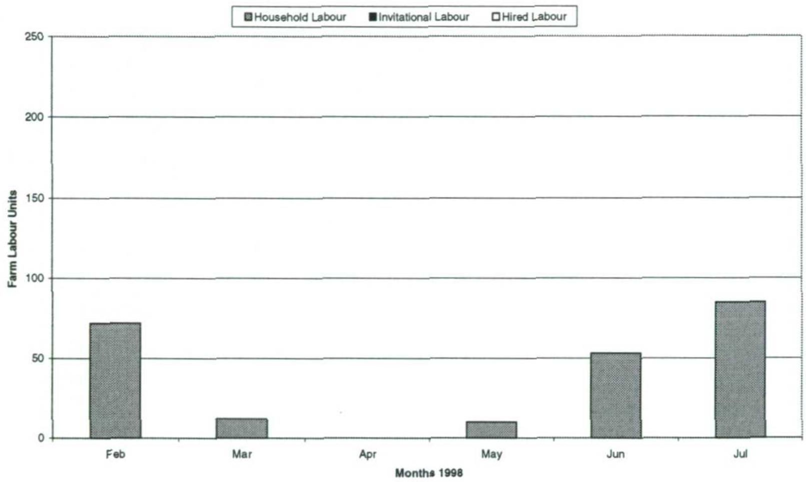
Note: This farmer created a higher labour force for weeding starts by using invitational labour.

12 Hamani Djibo

(a)



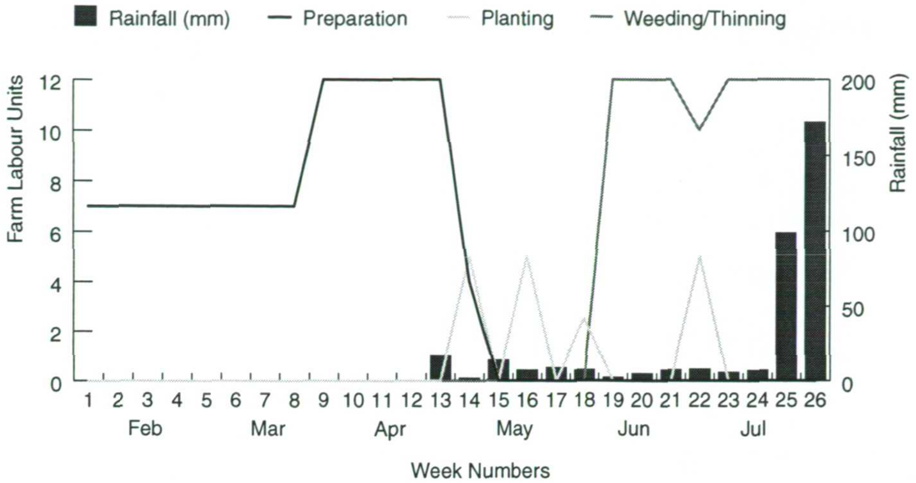
(b)



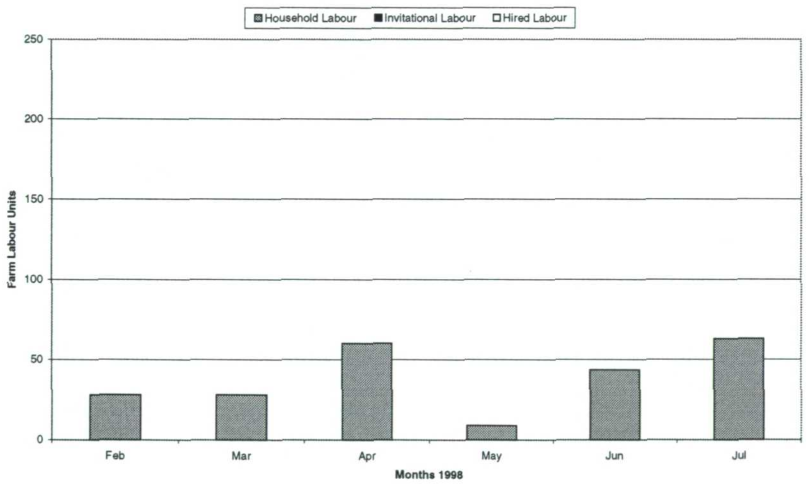
Note: This farmer replanted his millet crop twice before starting to plant other crops (reflected by the series of planting labour peaks).

13 Amadou Oumarou

(a)



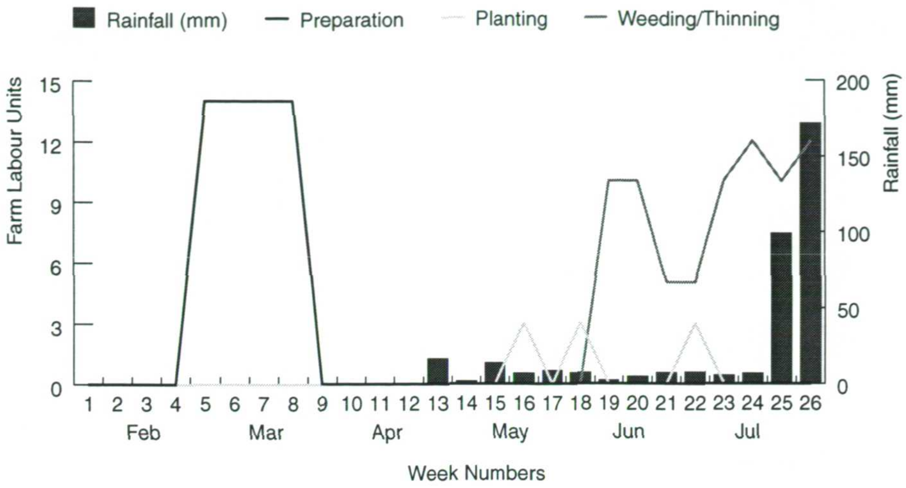
(b)



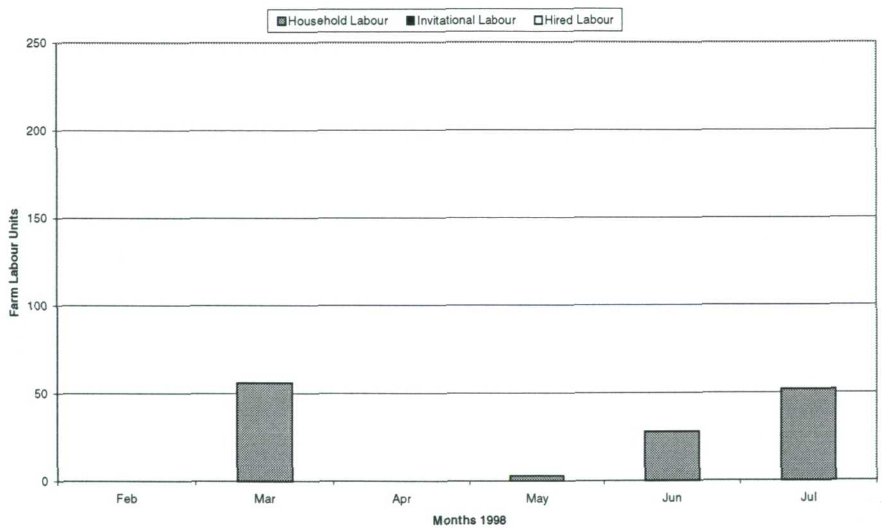
Note: Low labour supply for this farmer meant he was unable to complete preparation before the first rainfall event.

15 Marou Soumana

(a)



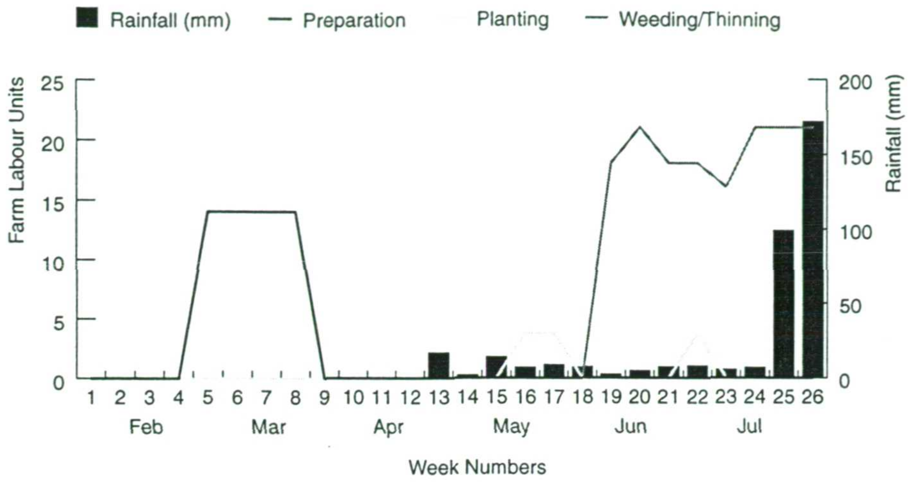
(b)



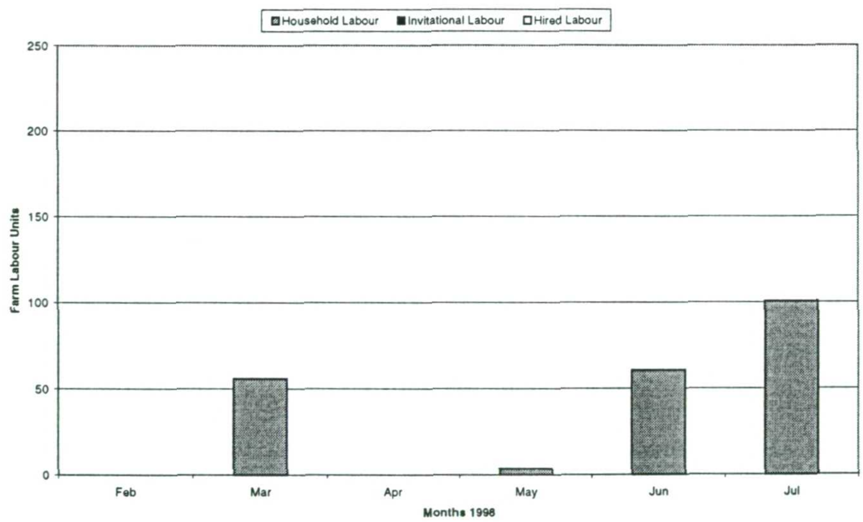
Note: This Fulani farmer had low labour supply although he was ready for the first rains.

16 Saley Moussa

(a)



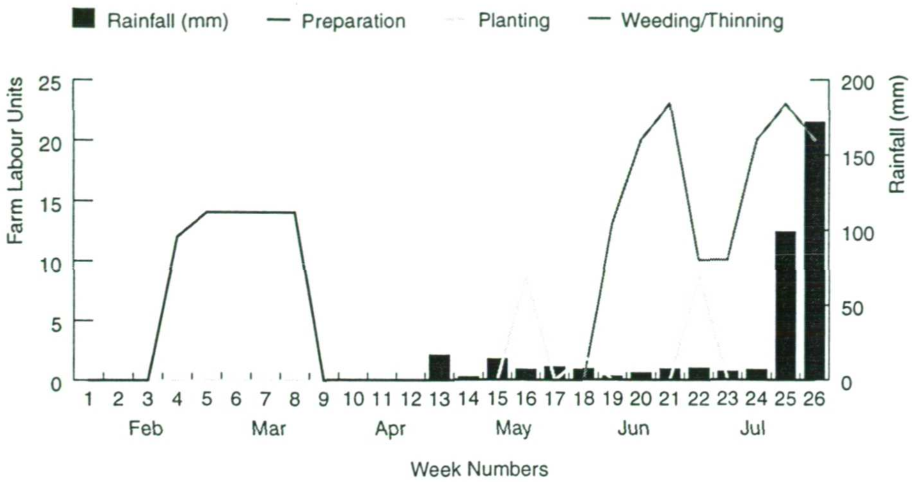
(b)



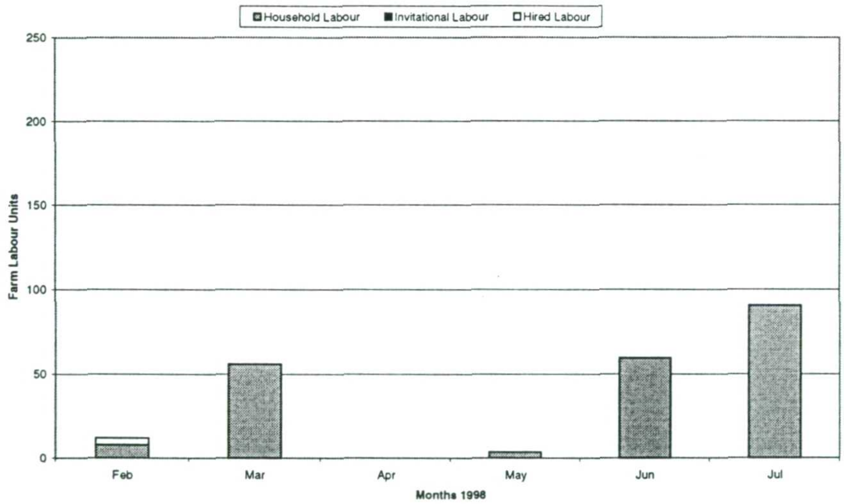
Note: This Fulani farmer had a larger family labour supply.

17 Moussa Soumana

(a)



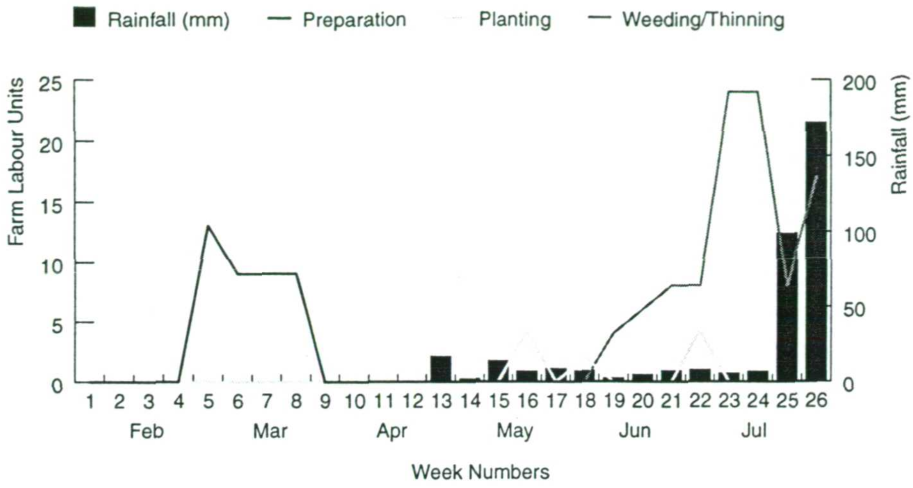
(b)



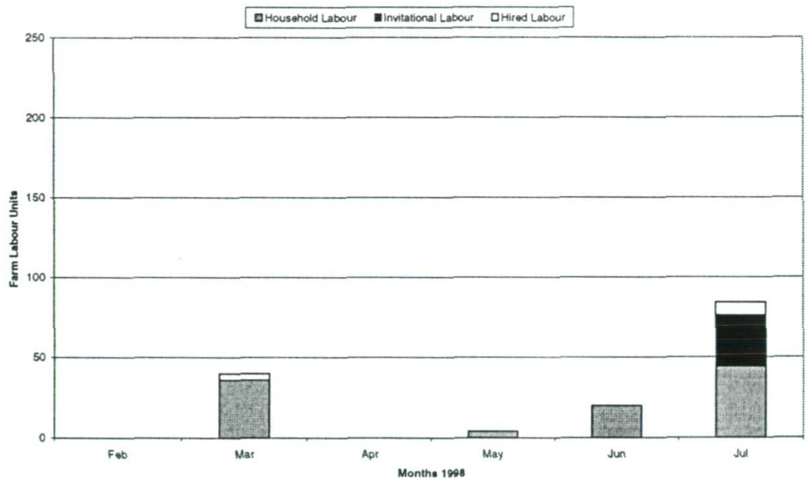
Note: The two planting strategy after the second large rainfall event.

18 Adamou Garba

(a)



(b)



Note: This farmer made up his low family labour for field preparation and weeding by hiring labourers and labour exchange (half the July labour was additional to household supply).

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Acknowledgements

This research was financed by an Economic and Social Research Council (grant No.R0042973459) and the Department of Geography, University College London. Professors Andrew Warren (Department of Geography) and Katherine Homewood (Department of Anthropology) supervised the study. I want to thank them for their advice, and for tirelessly reading my work.

Fieldwork was made possible with the help of various individuals and institutes. Permission to work in Niger was granted by President General Maïnassara, and in Fandou Béri by Chief Hamani Oumarou. I am grateful for the logistical co-operation I received while in Niger from Dr. John Bromley of the Institute of Hydrology (Oxford), M. Moussa Diolombi, Regional Finance Director of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Center and West African Programs (Niger), M. Bruno Gerard, Vehicles and Garage Manager at ICRISAT, Sadoré (Niger). I would like to thank the SERIDA Project (Social and Environmental Relations in Dryland Agriculture) for their co-operation, particularly Mr. Nik Taylor (research assistant in Niger) for his advice and help, and Dr. Simon Batterbury (Project Co-ordinator) for sharing data that I had not been able to collect during my fieldwork period.

In Niamey, I benefited from conversations with Dr. André Bationo (International Fertilizer Development Centre), Dr. Pierre Hiernaux (Centre International pour L'Elevage en Afrique/International Livestock Centre for Africa), Dr. François Achard (Institut de recherche pour le développement-IRD), Dr. Niek van Duivenbooden (ICRISAT), and Dr. Jean-Louis Rajot (IRD). I am particularly grateful to the time and help given by Drs. Andreas and Barbara Buerkert (formally at the University of

Hohenheim). I would like to thank the librarians at ICRISAT, Sadoré, and at IRD and AGRHYMET in Niamey.

During the course of this study, various individuals offered advice, help or comments. I would like to mention Dr. Tom Fearn, Dr. Frances Harris, Dr. Sian Sullivan, Prof. Paul Richards, Dr. Grace Carswell, Prof. Phil Burnham, Dr. Bill Adams, Dr. James Fairhead, Dr. Joost Brouwer, Dr. Beryl Turner, Dr. Leslie Gray, Dr. David Niemeijer and Dr. Matt Turner. Feedback from the Human Ecology Research Group (Department of Anthropology, University College London) was always helpful. I would also like to thank Prof. Jacquie Burgess for her support and my parents for their encouragement.

Siddo Seyni, my translator and field assistant, deserves special thanks. He fastidiously kept work schedules, was committed beyond his responsibility to maintaining good relationships with the villagers of Fandou Béri, and was an invaluable source of advice, information and humour. The quality of the data collected can be attributed to his skills at developing trust, making light of tension, and instigating serious debate.

Finally, I am deeply indebted to the villagers of Fandou Béri, who shared freely their knowledge and time, endured sensitive questions about all aspects of their lives, and received me with warmth and generosity.

This thesis is dedicated to Professor Silvio Piccardi, Department of Geography, University of Florence, who died before its completion.